COPY FOR MR. J. ALLAN ROSS

HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

CHAPTER "H"—CONSTRUCTION PLANT

EARTH AND ROCK EXCAVATION
CANAL

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS

Chapter H.

CONSTRUCTION PLANT

(Earth and Rock Excavation - Plant)

Walter J. Francis.

INDEX TO CHAPTER H.

Earth and Rock Excavation

Canal

INDEX TO CHAPTER H.

Earth and Rock Excavation

Canal

LIST OF ILLUSTRATIONS

Earth and Rock Excavation

Canal

(W-11322.)

LIST OF ILLUSTRATIONS

Earth and Rock Excavation

Canal

LIST OF ILLUSTRATIONS

Earth and Rock Excavation

Canal

LIST OF ILLUSTRATIONS

Earth and Rock Excavation

Canal

Chapter H.

CONSTRUCTION PLANT

Walter J. Francis.

Chapter H, dealing with Construction Plant, is divided into four parts of which this is the third, being a description of the plant devoted to the earth and rock excavation of the Canal. The first part of Chapter H dealt with the construction plant for concrete work; the second part with the plant used in transportation; while the fourth part treats of the construction plant used at the Intake, the Welland River, the Forebay, the Power House and the Tailrace.

CONSTRUCTION PLANT FOR EARTH AND ROCK EXCAVATION

Canal.

General.

The excavation of the earth and the rock in the Canal between Montrose and the Forebay at the Screen House constituted the most important single class of work in the whole development, involving as it did the removal of

about eleven million cubic yards of earth and about four million cubic yards of rock.

All of the earth and rock spoil was removed from the immediate site of the Canal. The greater part of the excavation was made in the dry, but that portion of the Canal lying between Montrose and the control gate was done as sub-aqueous work.

The first shovel, No. 7 (steam), commenced earth excavation at Bowman's Gully on May 10th, 1917, while the canal prism proper was started by shovel No. 3 (electric), on December 18th of the same year. The last shovel, No.12 (steam), finished and cut out on November 30th, 1921.

The sub-aqueous work of the Canal was commenced by the dredge "Cyclone" on March 14th, 1921, and was completed, about six months later, on September 3rd.

The Excavation Plant.

The Studies of the Type of Plant to be Used.

The question of the type of plant to be used in connection with the work was the subject of much study on the part of the engineers of the Hydro-Electric Power Commission, and particularly by Mr. Acres and Mr. Goodwin. In his reply to the comprehensive enquiries in regard to the development made by the Honourable Mr. Hearst, Prime Minister of Ontario, on December 12th, 1916,

Mr. W. W. Pope, Secretary of the Commission, made the following statement on January 12th, 1917, with reference to the qualifications and experience of those whom it was proposed to have carry on the construction work;

"The work will be carried out under the direction of the Chief Engineer of the Commission. Mr. Acres, the Hydraulic Engineer of the Commission, under whose direct supervision the scheme has been developed to its present stage, will have responsible charge of the canal construction and the hydraulic portion of the power installation. The immediate supervision of the construction work in the field will be under Mr. J. B. Goodwin, C.E. Mr. Goodwin is a specialist in hydraulic power construction, having had twenty years of experience devoted almost exclusively to this class of work. Mr. Goodwin had charge of the excavation work in the first wheel pit put down by the Niagara Falls Power Company in 1896. He afterwards had charge of the construction of the large tail water tunnel of the Electrical Development Company of Niagara Falls. Since that time he has been in responsible charge of construction on the large plant of the Pennsylvania Water and Light Company at McCall's Ferry, on the plant of the Mount Hood Power Company in the State of Washington, and for the Electric Power Company on the Trent River, besides doing a considerable amount of less important work which nevertheless required engineering ability of a high order.

"For more than two years past Mr. Goodwin has had direct charge in the field of all surveys and other preliminary work in connection with the Queenston Devolopment as well as the inspection and investigation of

working plans and installations in various parts of Canada and the United States, and the study of working methods as applied to heavy electrically driven construction plant. He will therefore undertake the construction work at Niagara with an intimate knowledge of conditions gained from his experience on the work up to the present time, and with a well developed conception of the difficulties to be encountered and the means to be taken to carry out the work within the estimates and within the time limit.

"Mr. Goodwin will have Mr. G. H. Angell as general superintendent of construction. Mr. Angell now occupies a similar position in connection with the construction of the Kensico Dam for the New York Water Supply System. This work is now practically completed at an actual cost of eight million dollars as against an estimated cost of about ten million dollars. The time allowed to complete the construction of this dam was nine years. Under Mr. Angell's direction the work was actually completed in six years. His professional record is attached hereto and requires no further explanation.

"Both Mr. Goodwin and Mr. Angell are Canadian born and are still Canadian citizens.

"The electric work in connection with the installation will be carried out by the expert electrical engineering staff of the Commission, in conjunction with the specialists on the staffs of the various electrical manufacturing companies."

His statement shows that, in addition to other work, for more than two years Mr. Goodwin had been giving special attention to the study of heavy

electrically-driven construction plant.

In the report of Mr. Acres, known as Report on Project No. 2 (quoted at length in Chapter K), under date of December 26th, 1917, he makes the following statement :

"A careful study of construction methods in connection with the excavation of earth and rock in the Canal was necessary by reason of certain existing conditions which would have a vital influence upon excavation cost. These conditions were, first, the availability of cheap electric power for operating construction plant; second, the large quantities of earth and rock to be removed, which made it possible to consider the use of excavating machinery of the heaviest type and largest capacity obtainable; and, third, the unusually good facilities available for the disposal of spoil, within short hauling distance, along the crest of the Niagara escarpment.

"Having the above conditions in mind, the Commission's Engineers spent several months in collecting and studying data in connection with the type of construction plant required. The operation of electric and steam driven excavating machinery was witnessed and studied in various parts of Canada and the United States and a large amount of information with reference to output, operating cost, working conditions, etc. was obtained and carefully analyzed.

"The result of this investigation was, that in January, 1917, when market conditions indicated that any further delay in the purchase of the plant would result in prohibitive prices and practically impossible

delivery dates, the Commission's Engineers were immediately able to recommend for purchase the type of plant best suited for carrying on the projected work.

"Practically all of the plant so purchased is now on the ground and a portion of it is in actual operation."

The engineers of the Hydro-Electric Power Commission decided that the excavation of the dry material in the Canal could best be done by specially built electrically-driven shovels, aided by a number of shovels of the ordinary size and type. Following the removal of the overburden of earth, the rock excavation was to be done by the same shovel plant. It was decided that the sides of the rock canal were to be cut down by channelling machines, and the body of the rock was to be drilled and blasted.

The earth and rock spoil were to be removed by means of a specially constructed railway system, already described in the second part of this Chapter under the head of "Transportation".

The sub-aqueous work was to be done by dredging.

As a result of the adoption of this general programme, the engineers of the Hydro-Electric Power Commission purchased from time to time a total of thirteen shovels, six of which were driven by steam and seven by electric energy, the bucket capacity varying between 7/8 of a cubic yard and 8 cubic yards. They also purchased twenty channellers, forty-four marine drills, sixty-three tripod drills, fifteen drifters, ninety hammer drills and one well drill, together with all the necessary accessories therefor.

In connection with the sub-aqueous work the necessary plant was rented.

List of Principal Items of Excavation Plant for Canal.

The following tables give the principal items of excavation plant used for the Canal, together with dates of purchase and the cost.

List of Shovels

Unit No.	Motive Power	Weight in Tons	Bucket Capacity in Cu.Yds.	Make	Model Number	Date of Purchase	Cost
1	Electric	332	8	Bucyrus	225-B	March 28,1917	$88,000
2	Electric	332	8	Bucyrus	225-B	March 28,1917	88,000
3	Electric	118	4½	Bucyrus	103-C	March 28,1917	43,865
4	Electric	118	4½	Bucyrus	103-C	March 28,1917	43,865
5	Steam	30	7/8	Bucyrus	18-B	March 28,1917	10,805
6	Electric	30	7/8	Bucyrus	18-B	March 28,1917	15,732
7	Steam	65	2½	Bucyrus	45	Sept. 13,1917	9,000
8	Electric	332	8	Bucyrus	225-B	July 6,1918	152,000
9	Electric	118	4½	Bucyrus	103-C	July 6,1918	73,785
10	Steam	35	1½	Bucyrus	35-B	May 10,1919	23,750
11	Steam	275	8	Marion	300	July 12,1920	142,350
12	Steam	332	8	Bucyrus	225-B	Aug. 14,1920	138,072
13	Ditcher	12	½	Keystone	4	Oct. 14,1919	5,900
14	Steam	83	2½	Marion	60	Nov. 1,1920	17,128

List of Other Excavating Plant

2 Jordan Spreaders, 100,000 lbs. capacity, with equipment
1 Bucyrus Spreader, 142,320 lbs. capacity, with equipment
1 Jordan Spreader, 80,000 lbs. capacity, with equipment
20 Sullivan Channellers
44 Marine Drills
63 Tripod Drills
15 Drifter Drills
90 Hammer Drills
1 Well Drill

Typical Photographs of Excavation Equipment.

Photograph No. H-51, included herewith as page H-101, shows one of the large electric shovels, shovel No. 1, in operation at Station 346+81, in August, 1913. The shovel is in the act of loading a car at a high elevation. The site is in the Canal cut on the northerly side of Bowman's Gully, stated by geologists to have been one of the buried channels of the Niagara River in past ages. In passing it is interesting to note the stratification exposed by the shovel which is working, the work track of which is about 70 feet below the natural surface on which the growing vegetation may be observed.

Photograph No. H-52, being the lower photograph on the page just mentioned shows one of the large steam shovels, shovel No. 11, loading earth into a car at a high elevation.

Photograph No. H-53, being the upper picture on page H-102 hereof, shows shovel No. 7, one of the smaller steam shovels, excavating earth about Station 14 in the immediate vicinity of Montrose, working out a shallow cut and loading the frozen earth into a dump car.

The lower photograph, No. H-54, on the last mentioned page, shows shovel No. 3, one of the medium size electric shovels, starting a cut on the surface near Montrose. This picture illustrates clearly a typical medium size electric shovel.

The upper photograph, No. H-55 on page H-103 hereof, shows a view of shovel No. 9 breaking the ground near Montrose, working in earth. This shovel is typical of one of the medium size electric shovels.

The lower photograph, No. H-56 on the last mentioned page, shows the upper

part of shovel No. 12, which is one of the large steam shovels, carrying through a 15-foot earth cut in the vicinity of Lundys Lane.

The upper photograph, No. H-57 on page H-104 hereof, shows shovel No. 4 on its arrival in 1917 ready for work. This shovel is the same as Nos. 3 and 9.

The lower photograph, No. H-58, on the last mentioned page, shows shovel No. 1, the first of the large electric shovels, commencing the earth cut working northwards from the edge of Bowman's Gully. This photograph, which shows the turntable of the shovel, and photograph No. H-51 on page H-101 give a comprehensive idea of the construction of shovels Nos. 1, 2 and 8.

Photograph No. H-59, the upper picture on page H-105 hereof, shows a group of channelling machines at work on the rock surface. Cutting tools are lying in the foreground.

The lower picture on the same page, No. H-60, shows the Keystone ditcher digging a drainage ditch.

The two photographs, being Nos. H-61 and H-62 on page H-106 hereof, give two views of batteries of marine drills. In the upper picture a battery of eight is shown working in the Canal near the Forebay, while the lower shows a battery of thirteen marine drills in the cut near Lundys Lane.

The upper picture, No. H-63 on page H-107, shows a Jordan spreader as used to distribute the earth on the disposal areas.

The lower picture, No. H-64 on the last mentioned page, shows a Bucyrus spreader widening out the dump on the main disposal area.

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To face page H-101

No. H-51

Photograph showing

Large Electric Shovel, No. 1, Excavating near Bowman's Gully.

Taken August 7th, 1918.

COPY

No. H-52

Photograph showing

Large Steam Shovel, No. 11, Excavating at Station 139.

Taken December 4th, 1920.


BUCYRUS


MARION SHOVEL—MODEL 300
HYDRO ELECTRIC POWER COMMISSION.
MARION
11

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To face page H-102

No. H-53

Photograph showing

Steam Shovel, No. 7, Excavating at Station 14.

Taken February 6th, 1920.

COPY

No. H-54

Photograph showing

Electric Shovel, No. 3, Breaking Ground at Station 149.

Taken May 5th, 1920.


210-CANAL
Shovel Breaking Ground
May 5 1920.

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To face page H-103

No. H-55

Photograph showing

Electric Shovel, No. 9, Breaking Ground near Montrose.

Taken April 6th, 1920.

COPY

No. H-56

Photograph showing

Large Steam Shovel, No. 12, Excavating near Landys Lane.

Taken March 3rd, 1921.

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To face page H-104

No. H-57

Photograph showing

Electric Shovel, No. 4, Ready to Work.

Taken December 12th, 1917.

COPY

No. H-58

Photograph showing

Large Electric Shovel, No. 1, Excavating at Station 340.

Taken May 15th, 1918.


BUCYRUS
BUCYRUS


HYDRO ELECTRIC POWER COMMISSION No 1
BUCYRUS

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To face page H-105

No. H-59

Photograph showing

Group of Sullivan Channellers.

Taken August 7th, 1919.

No. H-60

Photograph showing

Ditching Machine, No. 13, Digging at Station 73.

Taken February 6th, 1920.

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To face page H-106

No. H-61

Photograph showing

Battery of Marine Drills Working at Station 443.

Taken December 4th, 1919.

COPY

No. H-62

Photograph showing

Battery of Marine Drills Working at Lundys Lane.

Taken May 4th, 1921.

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To face page H-107

No. H-63

Photograph showing

Jordan Spreader No. 1.

Taken November 7th, 1919.

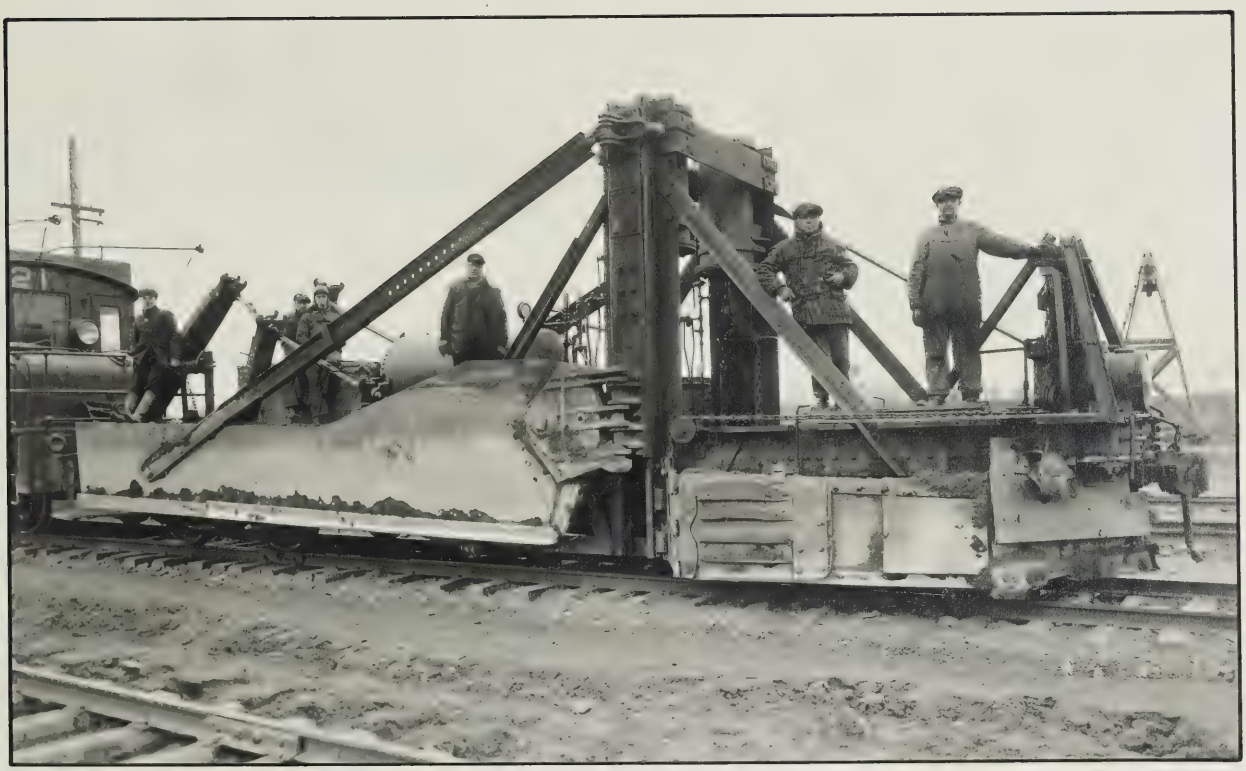
COPY

No. H-64

Photograph showing

Bucyrus Spreader Working on Main Disposal Area.

Taken January 7th, 1921.



General Dimensions of the Large Shovels.

In the latter part of the year 1916 the engineers of the Hydro-Electric Power Commission decided to utilize the largest shovels developed up to that time, for the reasons already set forth in Chapter G, page G-12, and in January, 1917, the necessary authority was given to purchase.

The first three large shovels purchased are known as 225-B revolving Bucyrus shovel equipped with an 80-foot boom and a 58-foot dipper stick for normal operations, and having a 90-foot boom for exceptionally high lifts. The weight of each shovel is 332 tons. Under normal conditions a 5-cubic yard dipper is used for rock excavation, and an 8-cubic yard dipper for earth. Equipped with the auxiliary parts these shovels can load cars standing on a track 70 feet above the track of the shovel, dig a cut with a bottom width of 120 feet, and load cars at the above height 88 feet sideways from the centre of the shovel. The motor equipment per shovel consists of two 162-horse-power hoist motors, one 122-horse-power swing motor, one 122-horse-power crowding motor, and one 10-horse-power compressor motor, a total rated motor capacity of 578 horse-power. Each shovel carries its own transformers which step down from the secondary feeder voltage of 4,000 to the motor voltage of 440.

The large shovels are mounted on two parallel tracks each of 36-inch gauge, the distance from centre to centre of tracks being 30 feet.

The working capacity of each of the shovels as given by the manufacturers is 5,000 cubic yards of earth or 3,000 cubic yards of rock per day of ten hours.

Two of these shovels, being Nos. 1 and 2, were ordered on March 28th, 1917, at a cost of $[illegible]8,000 each at Niagara Falls, Ontario. The third shovel, No. 8,

was ordered on July 6th, 1918, at a cost of $152,000 delivered.

As the work progressed, the engineers of the Hydro-Electric Power Commission decided to purchase two additional large shovels, but it was impossible to procure others of the same type. In July, 1920, however, they ordered a large Marion steam shovel, No. 11, being type No. 300, weighing 275 tons, and having other characteristics comparable with shovels Nos. 1, 2 and 8. On August 14th, 1920, they purchased a Bucyrus steam shovel, No. 12, similar in all respects to Nos. 1, 2 and 8, excepting that the motive power was steam.

Other Shovels.

The shovels Nos. 3, 4 and 9 were next in size to the largest. They were Bucyrus, Model 105-C, weighing 118 tons, equipped with a 3½-cubic yard bucket for rock, and a 4½-cubic yard bucket for earth, all electrically driven.

The capacity of these shovels as given by the makers is 3,500 cubic yards of earth or 2,000 cubic yards of rock per day of ten hours. Shovels Nos. 3 and 4 were ordered on March 28th, 1917, and cost $43,865 each at Niagara Falls. No. 9 was ordered on July 6th, 1918, and cost $73,785 at the same place.

Two of the shovels, Nos. 7 and 14, were steam shovels with a bucket capacity of 2½ cubic yards, the former being a Bucyrus shovel, Model 45, and the latter a Marion shovel, Model 60.

All the other shovels were smaller in size. Unit No. 13 in the table on page N-98 hereof is not a steam shovel but a small special machine used for ditching purposes. It is included in the table for the sake of completeness.

Dry Excavation Methods.

The general methods of handling the earth and rock excavation in the dry are comprehensively shown in a series of thirteen photographs Nos. H-65 to H-77 included herewith as pages H-114 to H-120 inclusive. The work of individual machines is shown to some extent in the series of photographs Nos. 51 to 64.

The earth overburden at the peak of the Canal cut near Lundys Lane was largely removed by the use of ordinary steam shovels in the usual way. The complete operations are shown in photograph No. H-65 on page H-114 hereof. The lifts were taken down in about 12-foot faces by this method, the service track for the spoil train being on the same general level as the service track of the shovel. Generally speaking, the shovels followed one another in order until the natural rock surface was uncovered. The large shovels were also used in this work, being put into commission on arrival, and generally speaking they worked on a face of 30 to 40 feet. On the northerly side of Bowman's Gully, shovel No. 1 worked against a face of over 80 feet in some cases.

After the removal of the earth overburden, the rock sides of the Canal were cut down with channellers to a depth of approximately 10 feet, and the body of the rock excavation was drilled with tripod drills or with marine drills according to the type of shovel to be subsequently used in the excavation, the tripod drills being used for the smaller shovels in shallow faces, and the marine drills where one of the five large shovels was to follow. Photograph No. H-66 shows the rock blasted in the vicinity of the Niagara, St.Catharines & Toronto Railway bridge ready for the shovel excavation. Photograph No. H-67

shows the result of blasting during 1919 near the Stanley Street diversion. The service track for the construction railway was laid close to the channelled cut and the shovels loaded directly into the train. These operations are clearly shown on photographs Nos. H-69 and H-70. The former photograph is a view of the work looking south from the Thorold Road temporary bridge, with shovel No. 2 working in the second bench in the middle distance, the first bench having already been excavated by shovel No. 4. Photograph No. H-70 shows shovel No. 9 excavating the first bench, near Victoria Street crossing, and loading the rock spoil into a standard electrically-hauled spoil train. This bench had a 10-foot face. The channelled surface may be clearly seen, and in the left foreground a quantity of spoil for lining the bank may be seen in place.

Photograph No. H-71 shows shovels 8 and 9 excavating the rock at Lundys Lane cut. The tripod drills are working in the foreground on the original rock surface. Blasted rock spoil is seen in the rear of the drills and on this spoil shovels No. 8 and No. 9 are working, No. 8 in advance of No. 9, No. 8 working on about a 20-foot face and No. 9 on about a 10-foot face. In this picture may be seen also the rock spoil used for lining the banks. In the distance the frames of a battery of marine drills are dimly outlined. Photograph No. H-72 was taken the same day as photograph No. H-71 looking in the opposite direction. In the immediate foreground shovel No. 8 is seen working on a 20-foot face. In advance of No. 8 may be seen the large Bucyrus steam shovel No. 12, cleaning up the earth slope on which the rock spoil is being deposited by a dirt train. Between the shovels are seen a battery of tripod drills and a battery of

channelling machines. In the far distance may be seen the frames of the marine drills. The two pictures, Nos. H-71 and H-72, show progressive rock work from marine drills on one bench to marine drills on the next with three shovels working progressively between them.

Photograph No. H-73 shows the progress in the rock in the Canal in August, 1920, at about Station 400, midway between Bowman's Gully and the Forebay. At this location the earth overburden is only 6 or 8 feet in depth. The first lift has been taken out and the channel cut of the side wall about 10 feet deep may be clearly seen. The rock in the Canal has been drilled by marine drills and the holes are being loaded with dynamite and the tamping rods may be seen in the foreground. In the background the dipper and the top of the boom of shovel No. 1, one of the large electric shovels, may be seen in the act of loading rock spoil into an electrically-hauled spoil train. In this case shovel No. 1 is working on a face of about 42 feet, with a 55-foot difference in elevation between shovel and loading tracks.

Photograph No. H-74 shows No. 2, the second of the large electric shovels, working southerly below the curve on the southerly side of the Portage Road on a working face of 30 feet, being the second bench in rock at this point. The shovel is in the act of loading a train. The channelled surface of the first bench may be clearly seen in the picture. The rock spoil has been deposited on the easterly or left-hand slope in the picture, while the placing of the spoil on the westerly or right-hand slope of the picture is still uncompleted. This rock spoil for protection lining was always deposited from the dump cars on the rip-rap track on the top of the slope. In the distance may be seen a battery

of marine drills in operation.

Photographs Nos. H-75 and H-76 are included to show in detail the class of rock spoil handled by the shovels. Both of these pictures were taken at Lundys Lane disposal area and are typical also of the character of excavated rock which was taken to the crushing plant to be prepared for concrete aggregate.

Photograph No. H-77 shows a picture of the rock excavation near the entrance to the Forebay, and is intended to illustrate the character of the excavated rock surface north of the Whirlpool, the lower 20 feet of the exposed face being shale and the upper portion limestone. Only one bench of channel cut was made, the rest of the rock face being formed by careful drilling and shooting as the lifts were carried downwards. It had been originally intended to leave the wall of the Canal unlined, but in order to increase the carrying capacity of the Canal it was decided to line the walls and floor with concrete, and thereby lessen the frictional resistance of the flowing water. Before the placing of the concrete, the walls were scaled down with hand tools.

Drilling.

As has already been stated, the drilling was done with standard tripod drills or with marine drills according to the depth of holes required. The drills were all driven by compressed air supplied from electrically-driven compressors in two principal stations, one of which was at Montrose and the other at the Whirlpool yards, and the air was delivered to the drills at a pressure of about 90 pounds per square inch, and for better efficiency was

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To face page H-114

No. H-66

Photograph showing

Blasted Rock Spoil Ready for Shovel
near Niagara, St. Catharines & Toronto Railway Bridge.

Taken August 5th, 1920.

COPY

No. H-65

Photograph showing

Earth Excavation Methods at Lundys Lane.

Taken December 2nd, 1920.

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To face page H-115

No. H-67

Photograph showing

Blasted Rock Broil Ready for Shovel at Station 298.

Taken August 7th, 1919.

COPY

No. H-68

Photograph showing

Excavation Methods Adjacent to Bowman's Gully.

Taken February 3rd, 1920.

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To face page H-116

No. H-69

Photograph showing

Canal Excavation Work,

looking south from Thorold Road Temporary Bridge.

Taken October 1st, 1919.

COPY

No. H-70

Photograph showing

Canal Excavation Work at Station 225.

Taken December, 1920.


Oct. 1. 1919.

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To face page H-117

No. H-71

Photograph showing

Canal Excavation Work at Station 155.

Taken May 4th, 1921.

COPY

No. H-72

Photograph showing

Canal Excavation Work at Station 158.

Taken May 4th, 1921.

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To face page H-118

No. H-73

Photograph showing

Loading the Drill Holes with Dynamite at Station 400.

Taken August 7th, 1920.

COPY

No. H-74

Photograph showing

Canal Excavation Work on Southerly Side of Portage Road.

Taken February 3rd, 1921.


Big Canal - B&O - No. 2 Shovel making 2nd
Rock cutting, S. side of Portage Rd
Curve
Feb. 5. 1921

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To face page H-119

No. H-75

Photograph showing

Typical Rock Spoil on Edge of Lundys Lane Disposal Area.

Taken October 11th, 1922.

COPY

No. H-76

Photograph showing

Typical Rock Spoil on Top of Lundys Lane Disposal Area.

Taken October 11th, 1922.

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To face page H-120

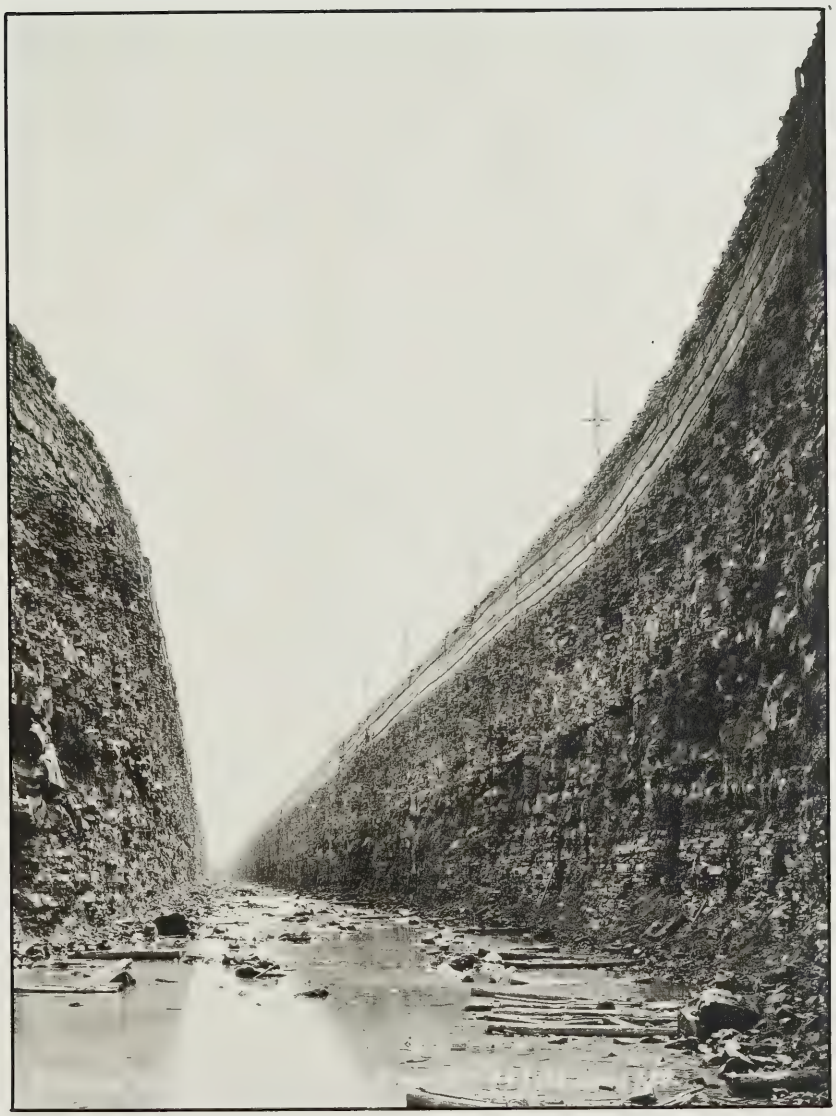
No. H-77

Photograph showing

COPY

Typical Finished Rock Excavation of Canal at Station 443.

Taken June 1st, 1920.



re-heated back of the hose connections.

The compressor plants had a capacity of 25,000 cubic feet of air per minute at a pressure varying from 110 to 125 pounds per square inch in the compressor plants. The air main was located on the westerly side of the Canal on the ground surface, and was made of flexible-coupled wrought-iron pipe in a single line varying from 10" to 8" diameter, fitted with a liberal number of off-takes.

The steel for the tripod drills was usually 1-3/8 inches in diameter. The marine drills used 2-inch steel, and gave a hole bottoming 2½ inches or more in diameter at 60-foot depth. The maximum depth of holes drilled by the marine drills was ordinarily sixty feet. The maximum number of marine drills in use at one time was thirty-eight and of tripod drills sixty.

The sides of the cutting were close-drilled for the second and the subsequent benches. When marine drills were used with a depth of sixty feet the close-drilling holes were at two-foot centres, while for tripod drills in fifteen-foot holes or less the close-drilling holes were at six-inch centres. In the body of the excavation the drilling was generally at seven-foot centres for the marine drills, and at six-foot centres for the tripod drills.

The diagrams included herewith as page H-122 show the amount of drilling done and the progress thereof. The total drilling in the Canal work was 2,554,491 lineal feet.

Blasting.

The blasting on the work was practically all done with 60 per cent.

ro-bucket book of the more economical.

The compressor plants had a capacity of 5,100 cubic feet of air per minute at a pressure varying from 110 to 130 pounds per square inch in the compressor plants. The air main was located on the westerly side of the canal on the ground surface, and was made of flexible-coupled wrought-iron pipe in a single line varying from 12" to 8" diameter. Fitted with a liberal number of off-takes.

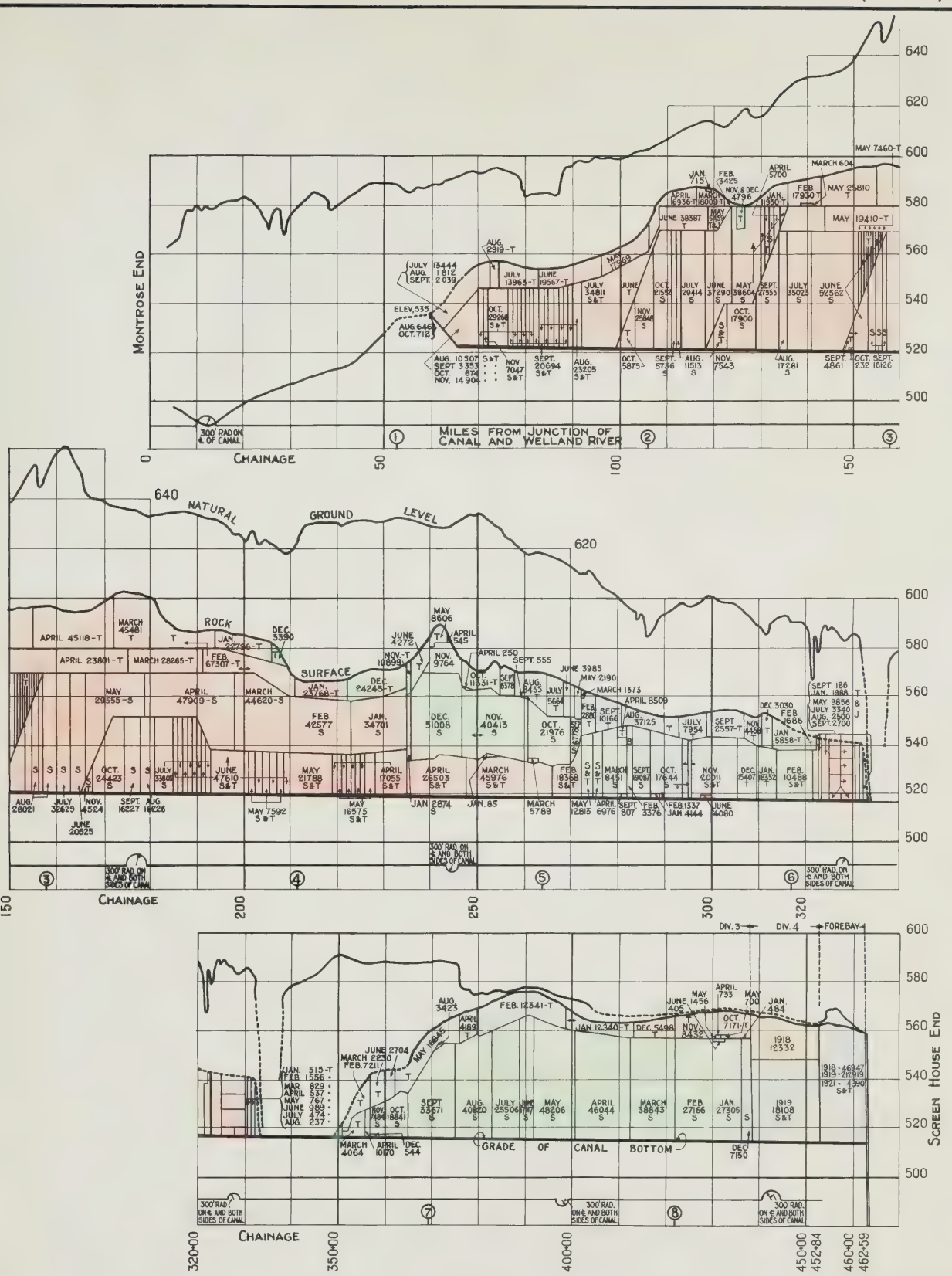
The steel for the tripod drills was usually 1-3/8 inches in diameter. The marine drills used 2-inch steel, and gave a hole bottoming 3/4 inches or more in diameter at 4-foot depth. The maximum depth of holes drilled by the marine drills was ordinarily 6 feet. The maximum number of marine drills in use at one time was thirty-eight and of tripod drills sixty.

The rides of the drilling were close-drilled for the manual and the mechanical barges. Then marine drills were used with a depth of sixty feet the close-drilling holes were of two-foot centres, while for tripod drills in fifteen-foot holes or less the close-drilling holes were at six-inch centres. In the body of the excavation the drilling was generally at seven-foot centres for the marine drills, and at six-foot centres for the tripod drills.

The diagrams included herewith as page R-123 show the amount of drilling done and the previous charges. The total drilling in the canal work was [illegible]

Blasting.

The blasting on the work was practically all done with 60 per cent.



NOTE:-
"T" INDICATES TRIPOD DRILLING
"S" " MARINE "
DRILLING SHOWN IN LINEAL FEET

LEGEND:-
1918
1919
1920
1921

SCALE OF FEET
HORIZONTAL
0 1000 2000 3000 4000 5000
0 20 40 60 80 100
VERTICAL

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY-CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

PROGRESS PROFILE DRILLING

Toronto, March 10th., 1923. Made by G.E.B., Checked by L.D.K.

WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

dynamite, but 40 per cent. was sometimes employed. In all 2,860 tons were used, being an average of 1.20 pounds per cubic yard of solid rock excavated.

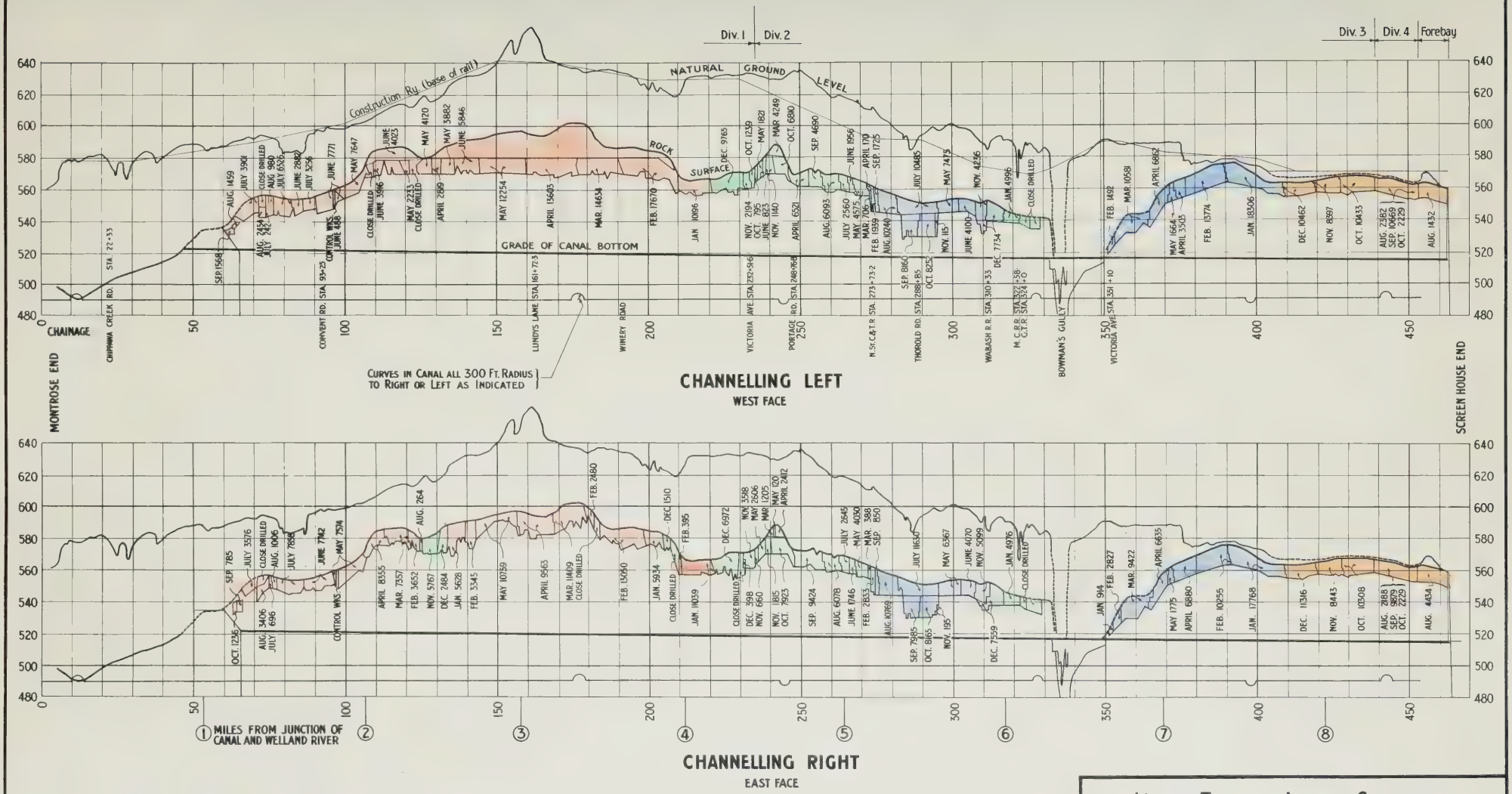
It was the practice to spring the deep holes three times before finally loading them, and to fire the close-drilling holes by delayed timing. The loading varied according to the stratification of the rock. For the springing shots the charge varied from one-half to one and one-half cases of dynamite, and the deep holes were finally loaded with about six cases each.

Channelling.

The channelling machines were operated from the same compressed air service as the drills. The maximum number of channelling machines in use at any time was nineteen, all of standard Sullivan make. It had been originally intended to channel the whole of the side faces of the Canal, but the subsequent decision to line the rock section rendered channelling unnecessary beyond the depth of the first bench. The diagrams included herewith as page H-124 show the amount of channelling done and the progress thereon. The total surface area of channelling in the Canal work was 716,475 square feet.

Excavation Progress.

The two charts shown on page H-125 hereof show the percentage progress of earth and rock excavation month by month throughout the continuance of the work, while the chart included as page H-126 hereof shows the total quantity excavated month by month, accounting for the removal of 10,907,525 cubic yards of earth,



NOTE: CHANNELLING SHOWN IN SQUARE FEET

LEGEND

1918
1919
1920
1921

SCALE OF FEET

HORIZONTAL

0 1000 2000 3000 4000 5000

0 20 40 60 80 100

VERTICAL

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY-CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

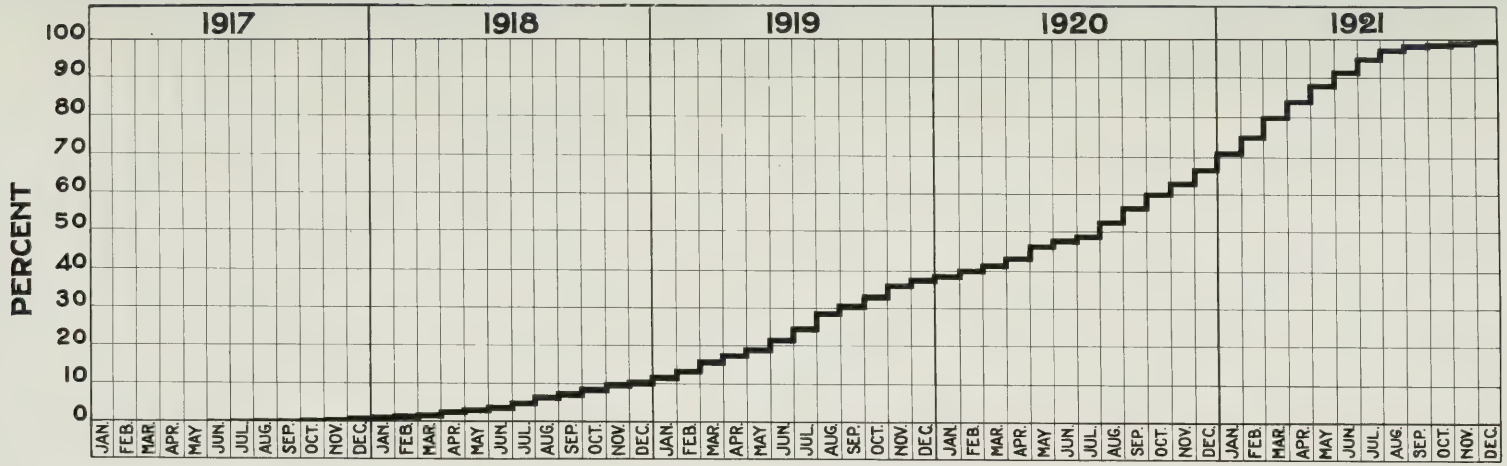
PROGRESS PROFILE CHANNELLING

Toronto, March 10th., 1923. Made by S.R.W., Checked by C.L.H.

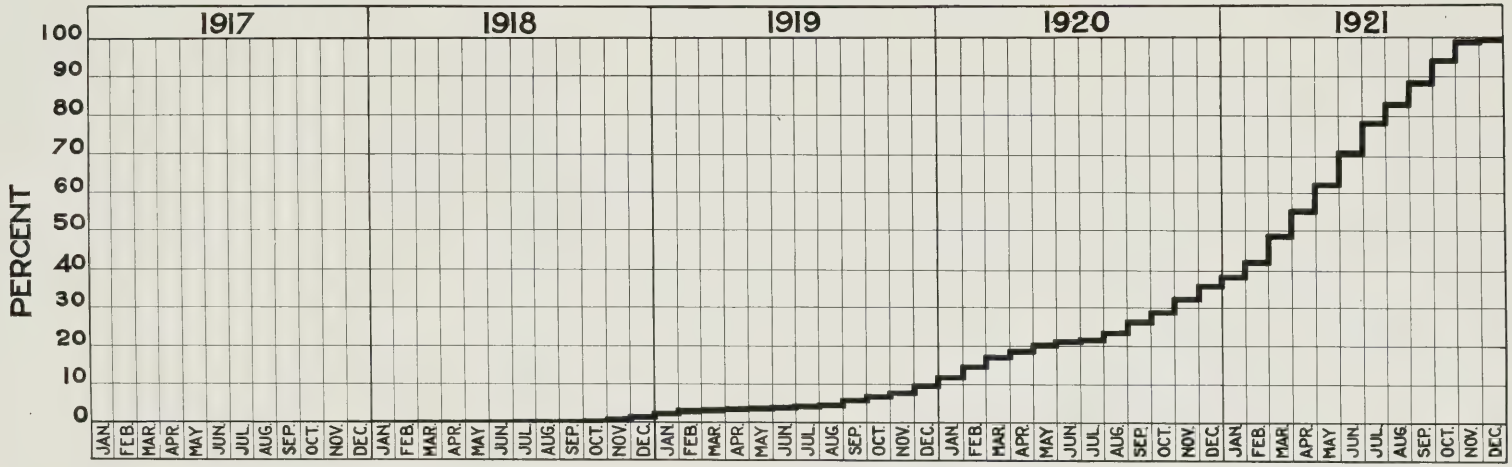
WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(H-124)



EARTH EXCAVATION



ROCK EXCAVATION

HYDRO-ELECTRIC INQUIRY COMMISSION

W. D. GREGORY-CHAIRMAN

QUEENSTON-CHIPPAWA POWER DEVELOPMENT

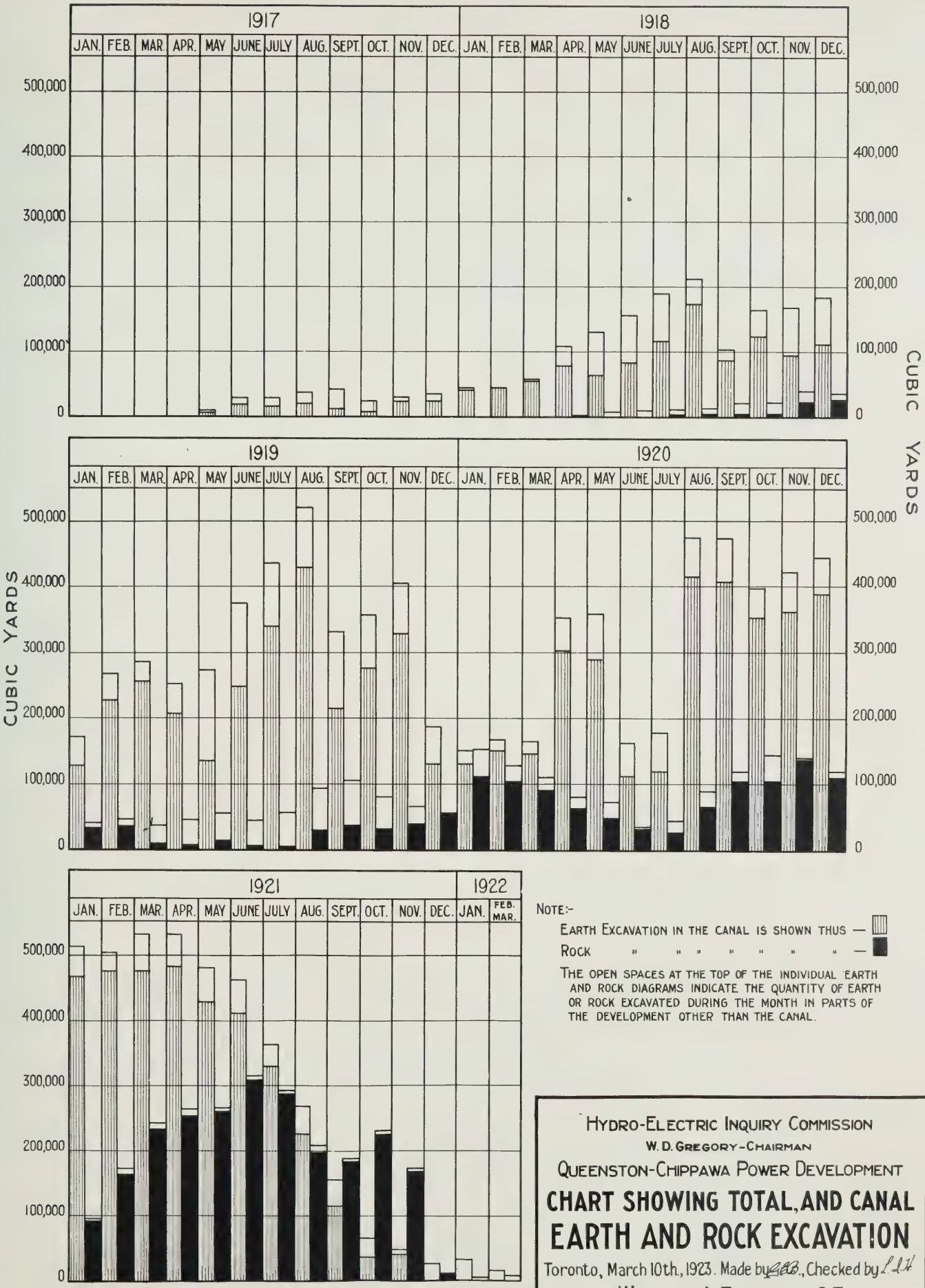
PERCENTAGE PROGRESS CHARTS
EARTH AND ROCK EXCAVATION

Toronto. March 10th., 1923. Made by Checked by

WALTER J. FRANCIS, C.E.,

CONSULTING ENGINEER

(H-125)


1917
1918
1919
1920
1921
1922
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
FEB. MAR.
500,000
400,000
300,000
200,000
100,000
0
CUBIC YARDS
NOTE:-
EARTH EXCAVATION IN THE CANAL IS SHOWN THUS —
ROCK " " " " " " " —
THE OPEN SPACES AT THE TOP OF THE INDIVIDUAL EARTH AND ROCK DIAGRAMS INDICATE THE QUANTITY OF EARTH OR ROCK EXCAVATED DURING THE MONTH IN PARTS OF THE DEVELOPMENT OTHER THAN THE CANAL.
HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY-CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT
CHART SHOWING TOTAL, AND CANAL
EARTH AND ROCK EXCAVATION
Toronto, March 10th., 1923. Made by GEB., Checked by L.L.H.
WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

and 3,840,378 cubic yards of rock.

The chart included herewith as page H-128 gives the average number of trains per day required to transfer the material to the main disposal areas, and to the crushers and the rip-rap work. This chart was plotted from voluminous train records made during the construction period. The two pages included herewith as H-129 and H-130 give the same information in figures.

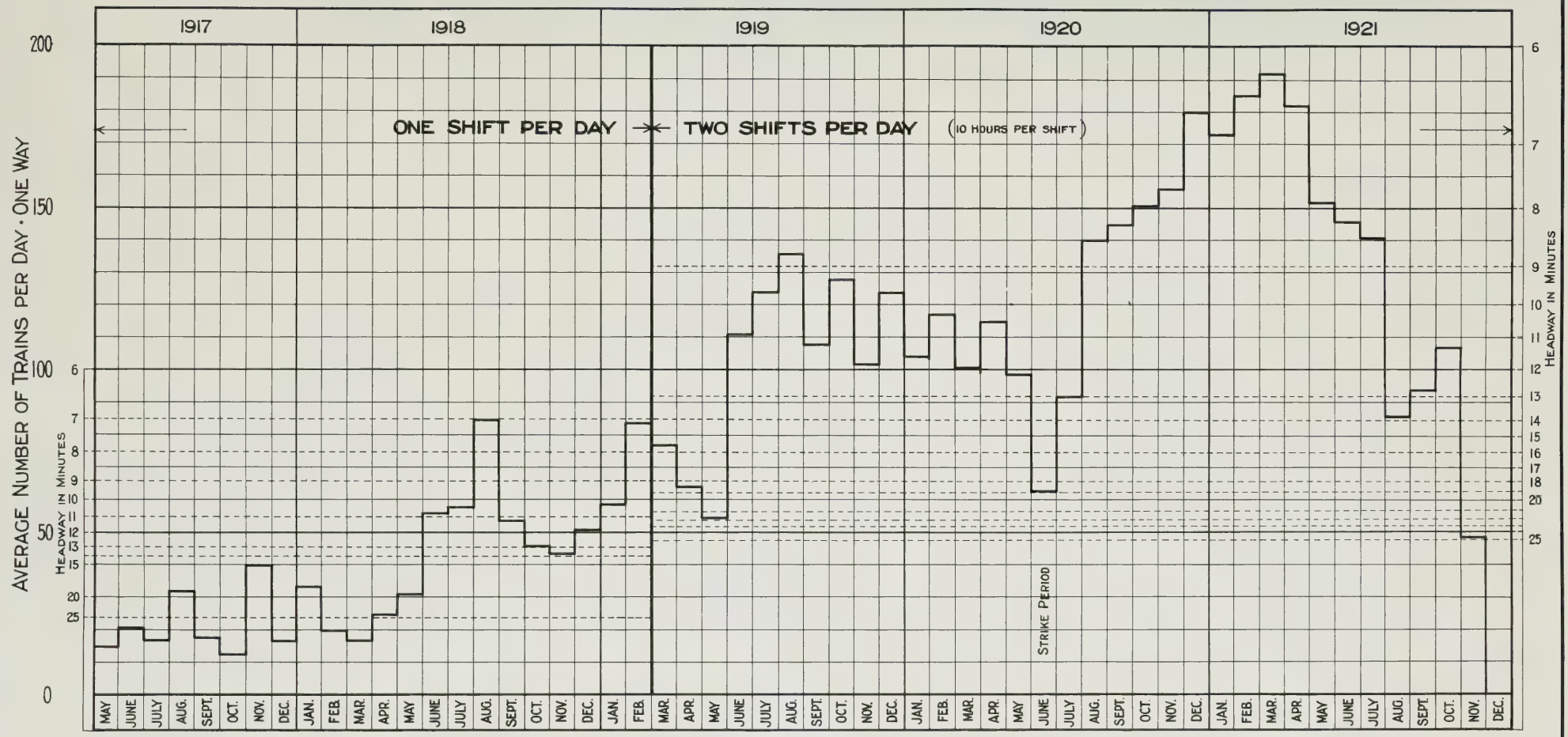
The ten pages included herewith as H-131 to H-140, inclusive, show progressively the location and operation of each of the excavation units month by month, being a graphic supplement to the information given on pages H-141 to H-146 inclusive.

COPY

Unwatering.

The unwatering for the excavation work of the canal was accomplished by the digging of side ditches for the disposal of the surface water, and later by pilot shovel cuts down to the rock surface into which sump holes were made. The sumps were pumped out by means of electrically-driven centrifugal pumps in some cases, while in others duplex steam pumps were used with compressed air as the motive power.

In the work at Bowman's Gully the unwatering was done by means of a centrifugal pump mounted on a scow so that the variations in the water level could be followed by the pump without disturbing its setting.



NOTE:-
THE DOTTED HORIZONTAL LINES DENOTE INTERVALS BETWEEN TRAINS, IN MINUTES.

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY-CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

TRAINS TO DISPOSAL AREAS
AVERAGE NUMBER PER DAY, BY MONTHS

Toronto, March 10th., 1923. Made by GEB. Checked by LLH.

WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER

(H-128)

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Queenston-Chippawa Power Development

Table showing Daily Train Movement, one way.

	E.S. #1	E.S. #2	E.S. #3	E.S. #4	S.S. #5	E.S. #6	S.S. #7	E.S. #8
1917:								
May							192	
June							503	
July							426	
August					453		328	
September					208		69	
October					131		55	
November					514	369	147	
December			116		-	189	86	
Totals			116		1,306	558	1,806	
1918:								
January			207	86	221	511	-	
February			154	79	-	196	-	
March	102		250	91	-	-	-	
April	371		55	121	-	101	-	
May	557	73	-	102	-	120	-	
June	397	105	49	101	615	142	-	
July	634	-	147	115	426	177	-	
August	888	339	132	35	760	114	30	
September	36	456	181	231	231	87	85	
October	558	291	74	196	-	120	1	
November	484	165	-	237	-	113	152	
December	372	355	68	244	-	23	105	
Totals	4,399	1,764	1,337	1,644	2,253	1,504	373	
1919:								
January	475	616	27	416	-	-	56	
February	439	1,054	17	461	-	27	94	
March	931	828	113	190	7	28	58	
April	805	607	173	206	-	44	-	
May	438	500	205	84	-	61	-	73
June	522	687	67	27	-	34	-	488
July	568	697	-	14	-		43	993
August	561	350	104	160	-		366	1,102
September	508	293	138	163	-		501	717
October	558	406	499	-	-		289	933
November	-	507	562	-	-		273	755
December	8	576	452	-	114		221	374
Totals	5,813	7,121	2,357	1,721	121	194	1,901	5,433

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross. (H-129)

Canal Excavation Only

between Shovels and Disposition Points

E.S. #9	S.S. #10	S.S. #11	S.S. #12	S.S. #14	Misc. Equip.	Total Trains	Days per Month	Average Number of Trains per Day by Months
						192	13	15
						503	25	21
						426	24	17
						781	24	32
						277	15	18
						186	14	13
						1,030	26	40
						391	23	17
						3,786		
						825	25	33
						429	21	20
						449	27	17
						648	26	25
						852	27	31
						1,409	25	56
						1,519	26	58
						2,298	27	85
						1,287	24	54
						1,240	27	46
						1,151	26	44
						1,167	23	51
						13,274		
						1,590	27	59
						2,092	25	84
						2,155	28	77
29						1,864	29	64
69					9	1,439	26	55
816	44				90	2,775	25	111
590	96				100	3,101	25	124
880	57				94	3,674	27	136
200	42				139	2,701	25	108
590	16				40	3,321	26	128
374	17				54	2,540	25	102
1,160	14				56	2,975	24	124
4,708	286				582	30,257		

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Queenston-Chippawa Power Development

Table showing Daily Train Movement, one way.

	E.S. #1	E.S. #2	E.S. #3	E.S. #4	S.S. #5	E.S. #6	S.S. #7	S.S. #8
1920:								
January	764	463	372	-	201	.....	308	436
February	679	432	230	-	209	.....	244	592
March	870	140	295	-	-	.....	411	677
April	708	707	228	-	-	.....	340	358
May	555	348	481	-	-	.....	164	555
June	248	-	84	-	-	.....	-	356
July	421	468	283	-	16	.....	-	429
August	583	604	606	-	23	.....	153	912
September	610	346	681	-	10	.....	510	1,111
October	683	339	323	59	3	.....	439	879
November	589	475	375	550	-	.....	404	587
December	498	591	344	448	-	.....	332	747
Totals	7,208	4,913	4,304	1,057	462	-	3,305	7,639
1921:								
January	133	518	370	449	-	.....	322	786
February	439	550	209	190	19	.....	231	532
March	747	738	304	84	16	.....	186	726
April	601	730	164	134	-	.....	146	608
May	606	696	270	215	-	.....	6	569
June	627	672	207	209	-	.....	-	561
July	560	500	248	182	-	.....	-	546
August	376	432	153	59	-	.....	-	332
September	394	478	148	45	4	.....	-	310
October	502	340	61	66	22	.....	-	675
November	68	366	-	-	-	.....	-	-
Totals	5,053	6,020	2,134	1,633	61	-	891	5,645

Note: E.S.#1 denotes Shovel #1, Electric.
S.S.#5 denotes Shovel #5, Steam.

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

(H-130)

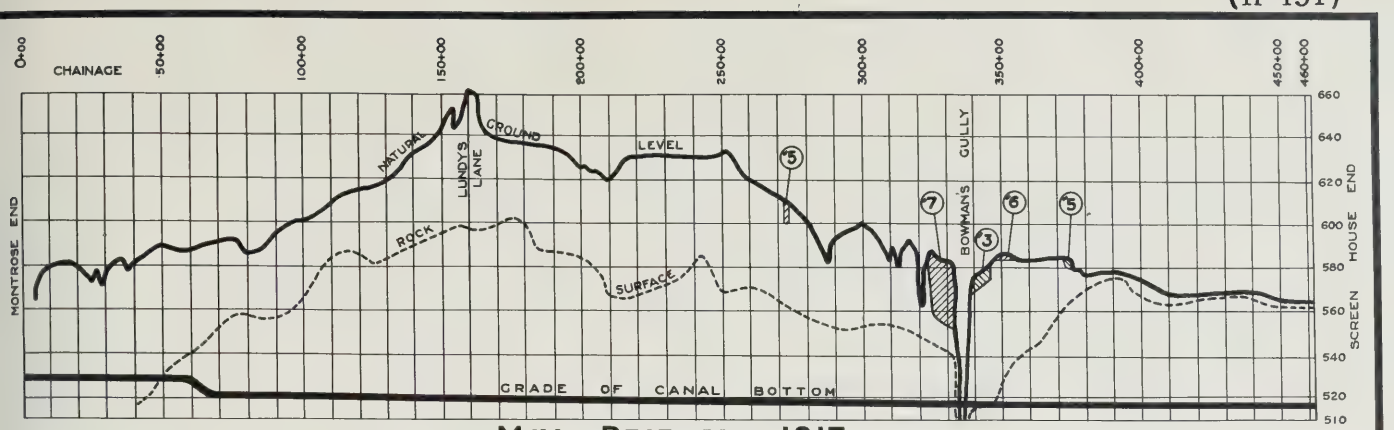
Canal Excavation Only

between Shovels and Disposition Points (Continued)

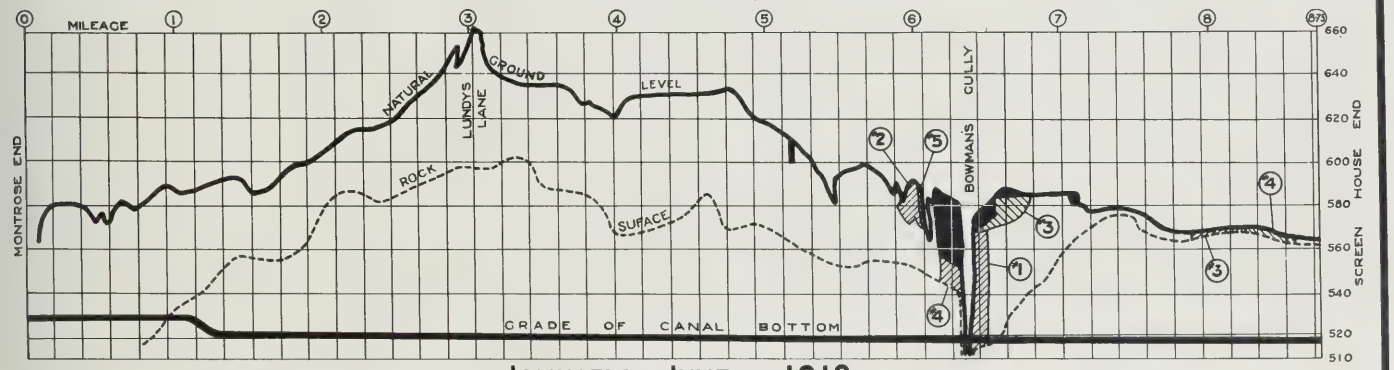
E.S. #9	S.S. #10	S.S. #11	S.S. #12	S.S. #14	Misc. Equip.	Total Trains	Days per Month	Average Number of Trains per Day by Months
154	83				24	2,805	27	104
159	46				90	2,681	23	117
233	-				94	2,720	27	101
484	-				48	2,873	25	115
315	-				46	2,464	25	99
126	-				5	819	13	63
213	-				14	1,844	20	92
604	109				36	3,632	26	140
315	197				-	3,780	26	145
254	157	411			-	3,547	25	151
281	71	808	75	9	-	4,224	27	156
243	106	672	666	-	29	4,676	26	180
3,381	769	1,891	741	9	386	36,065		
259	57	801	622	157	21	4,495	26	173
360	108	1,080	784	325	-	4,827	26	185
385	140	965	903	364	1	5,559	29	192
438	226	945	897	356	29	5,274	29	182
133	42	1,196	482	305	57	4,557	30	152
289	-	1,069	504	351	6	4,495	30	146
394	-	342	417	625	-	3,814	27	141
355	-	351	183	62	13	2,316	27	86
311	-	408	350	-	15	2,463	26	94
-	-	648	466	-	114	2,894	27	107
-	-	445	376	-	31	1,286	26	49
2,924	573	8,250	5,984	2,545	267	41,980		

COPY

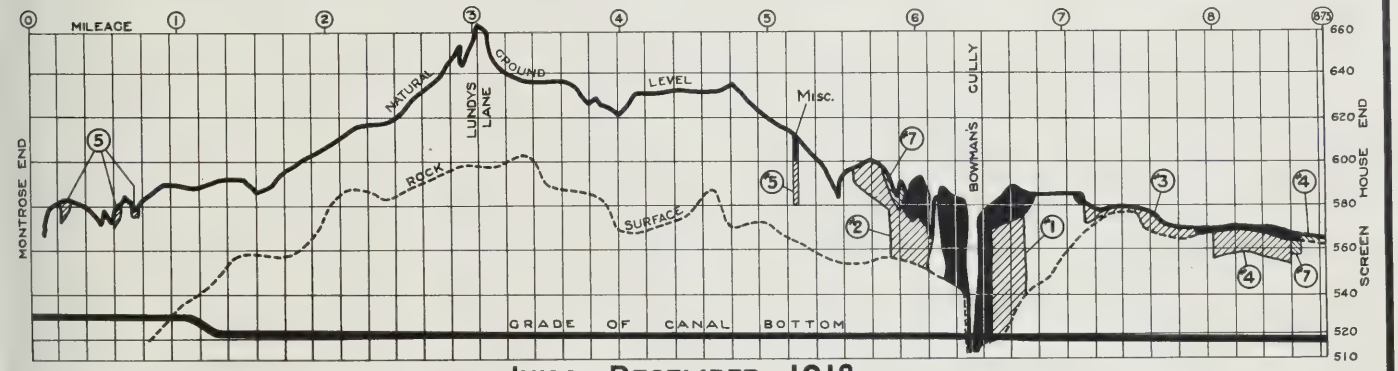
MAY 1917 TO JANUARY 1919



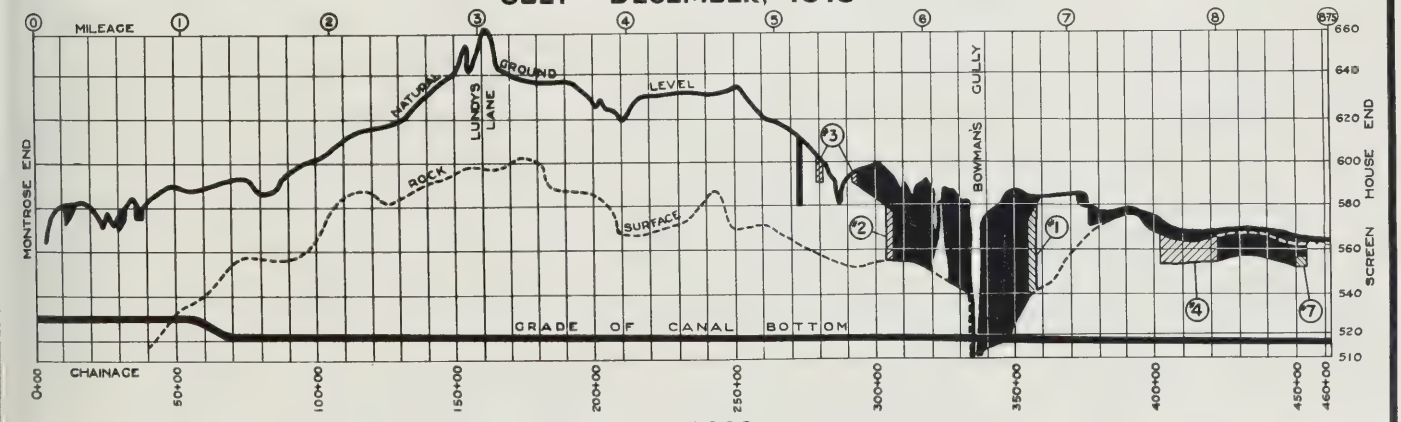
MAY – DECEMBER, 1917



JANUARY – JUNE, 1918



JULY – DECEMBER, 1918



MONTH OF JANUARY, 1919

MAY, 1917 TO JANUARY, 1919

EXCAVATION DURING MONTH INDICATED, SHOWN THUS:-
COMPLETED PRIOR TO MONTH INDICATED, SHOWN IN BLACK
EXCAVATING UNITS SHOWN THUS:- (1)
MILEAGE SHOWN THUS:- (4)
ELEVATIONS ARE REFERRED TO H.E.P.C. DATUM

Scale of Feet
Horizontal
0 5000
Vertical
0 10 20 30 40 50 60 70 80 90 100

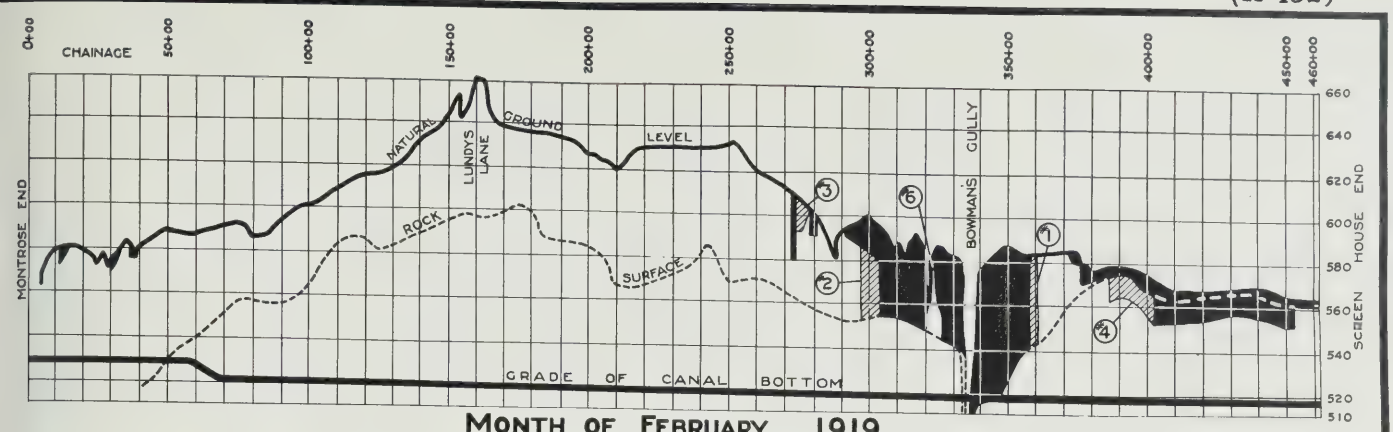
HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY-CHAIRMAN
QUEENSTON-CHIPPAWA POWER DEVELOPMENT

CANAL EARTH AND ROCK EXCAVATION PROGRESS CHARTS

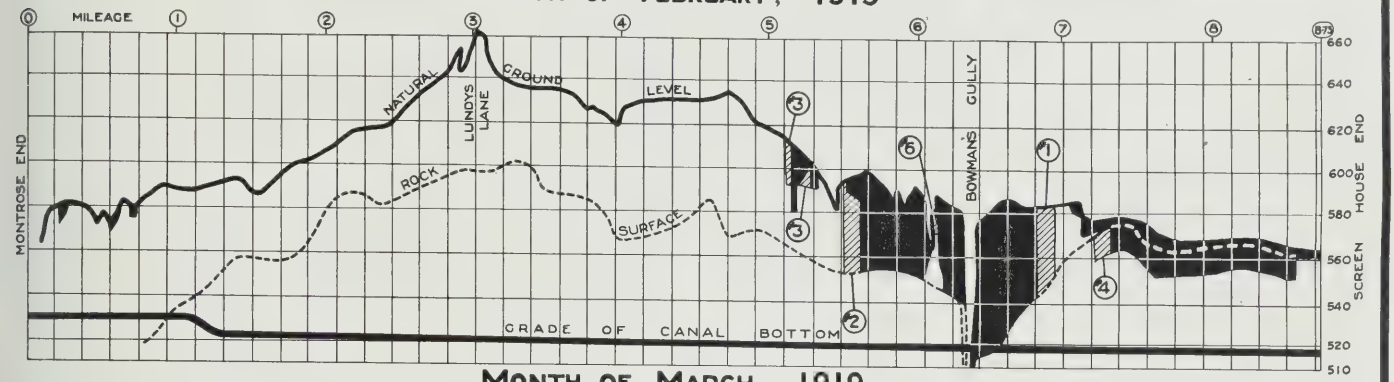
SHEET 1 OF A SERIES OF 10 SHEETS

Toronto, Mar. 10th, 1923. Made by [illegible], Checked by [illegible]

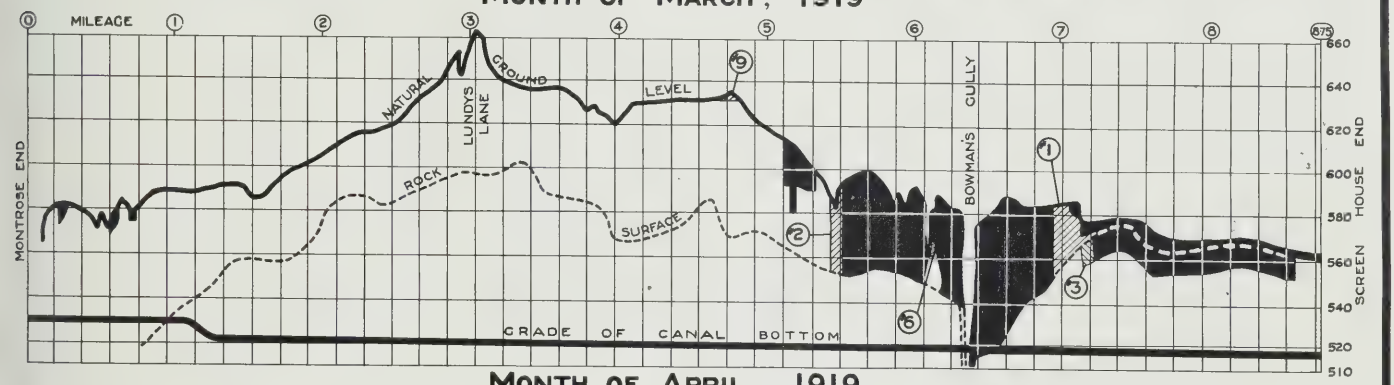
WALTER J. FRANCIS, C.E.,
CONSULTING ENGINEER



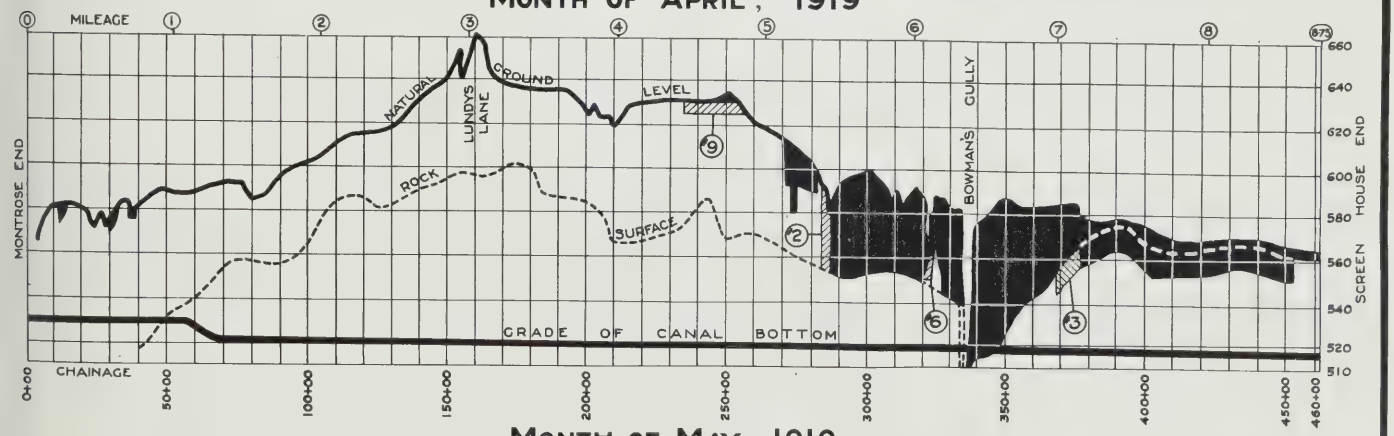
MONTH OF FEBRUARY, 1919



MONTH OF MARCH, 1919



MONTH OF APRIL, 1919



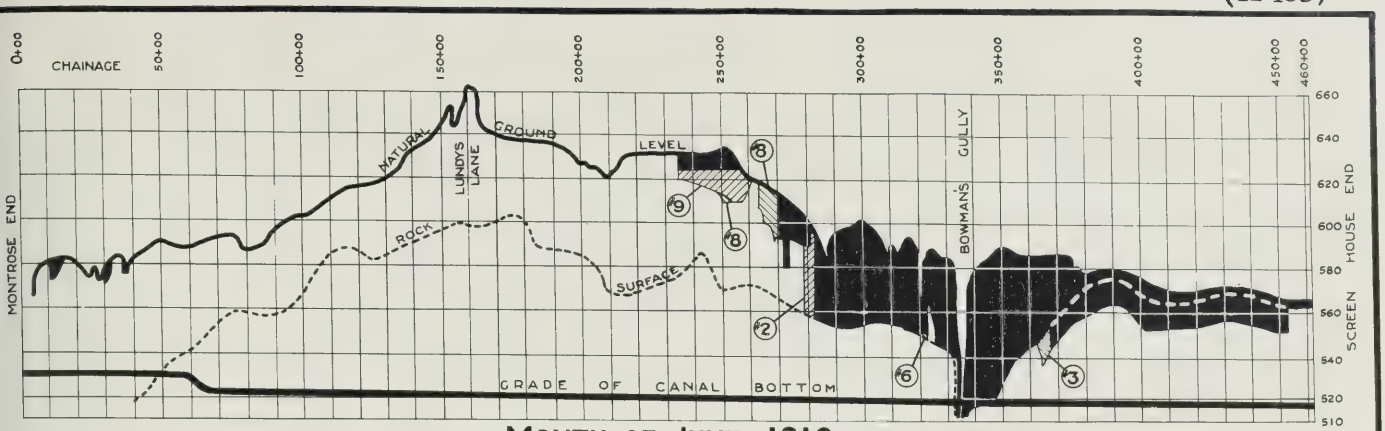
MONTH OF MAY, 1919

FEBRUARY, 1919 TO MAY, 1919

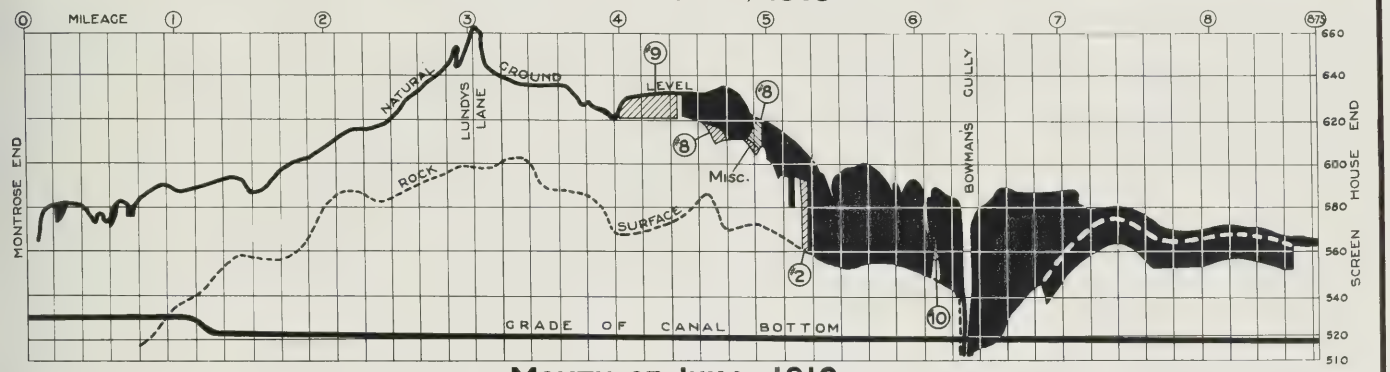
EXCAVATION DURING MONTH INDICATED, SHOWN THUS:-
" COMPLETED PRIOR TO MONTH INDICATED, SHOWN IN BLACK
EXCAVATING UNITS SHOWN THUS:- (1)
MILEAGE SHOWN THUS:- (4)
ELEVATIONS ARE REFERRED TO M.E.P.C. DATUM

Scale of Feet
Horizontal
0 5000
Vertical
0 10 20 30 40 50 60 70 80 90 100

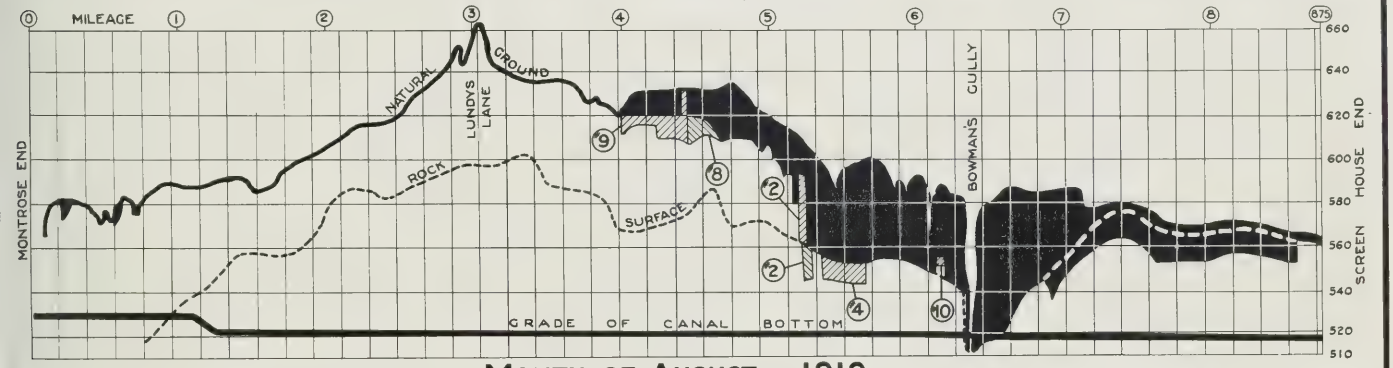
SHEET 2



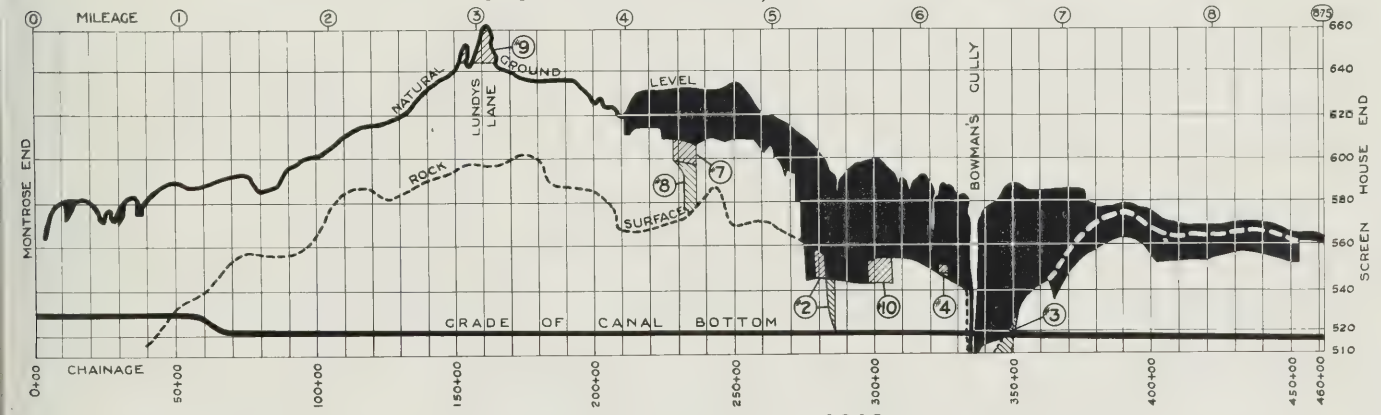
MONTH OF JUNE, 1919



MONTH OF JULY, 1919



MONTH OF AUGUST, 1919



MONTH OF SEPTEMBER, 1919

JUNE, 1919 TO SEPTEMBER, 1919

EXCAVATION DURING MONTH INDICATED, SHOWN THUS:-

COMPLETED PRIOR TO MONTH INDICATED, SHOWN IN BLACK

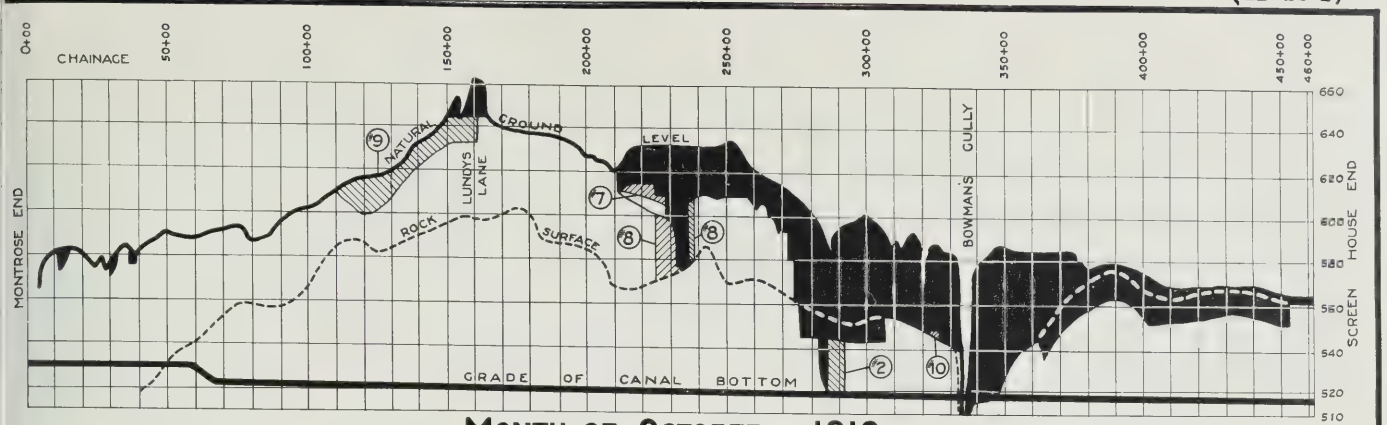
EXCAVATING UNITS SHOWN THUS:- (#1)

MILEAGE SHOWN THUS:- (4)

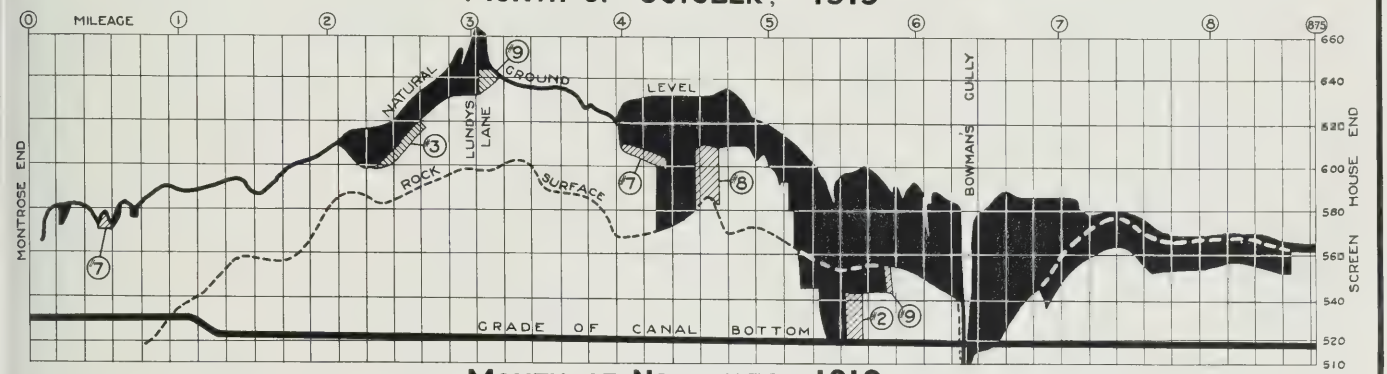
ELEVATIONS ARE REFERRED TO H.E.P.C. DATUM

Scale of Feet
Horizontal 0 5000
Vertical 0 10 20 30 40 50 60 70 80 90 100

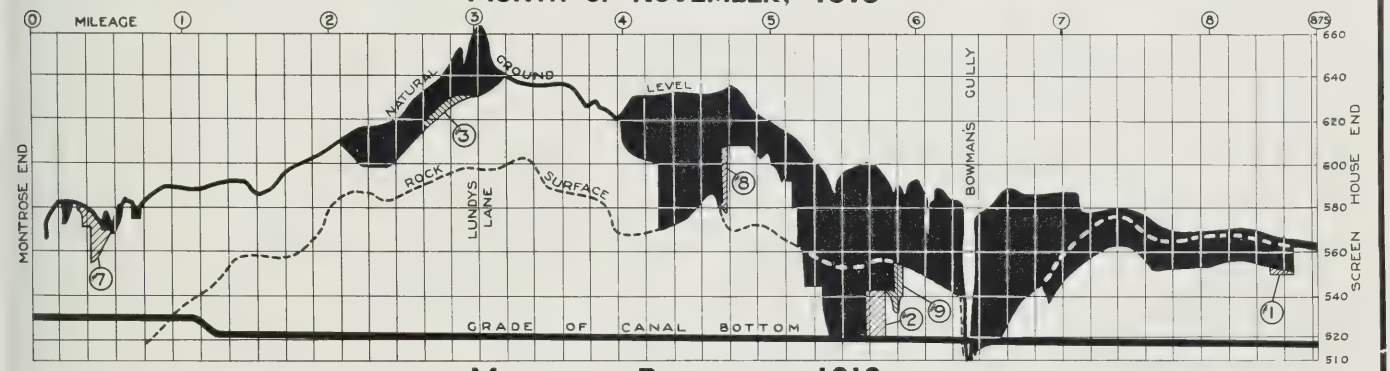
SHEET 3



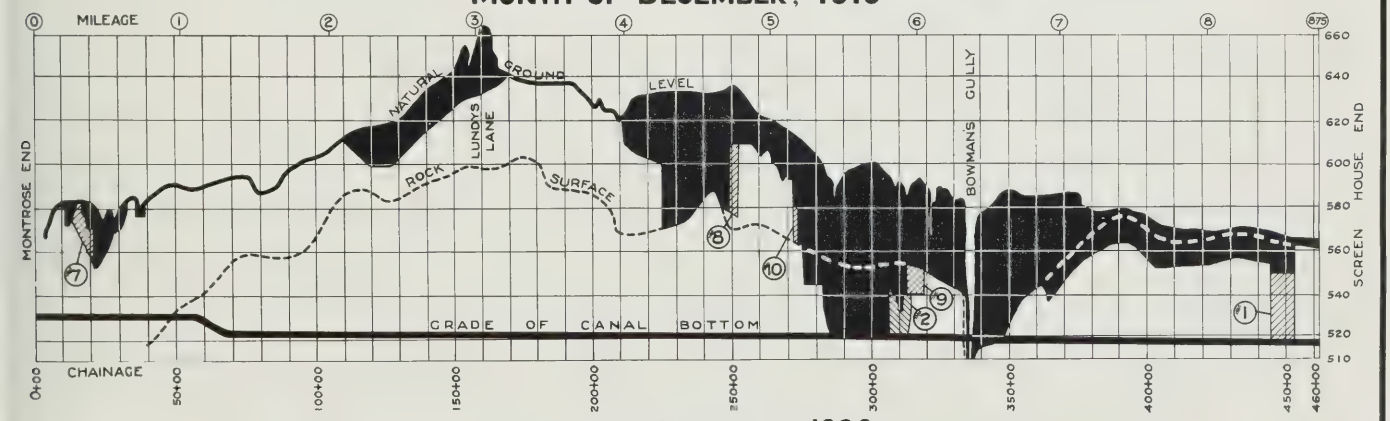
MONTH OF OCTOBER, 1919



MONTH OF NOVEMBER, 1919



MONTH OF DECEMBER, 1919



MONTH OF JANUARY, 1920

OCTOBER, 1919 TO JANUARY, 1920

EXCAVATION DURING MONTH INDICATED, SHOWN THUS:-

COMPLETED PRIOR TO MONTH INDICATED, SHOWN IN BLACK

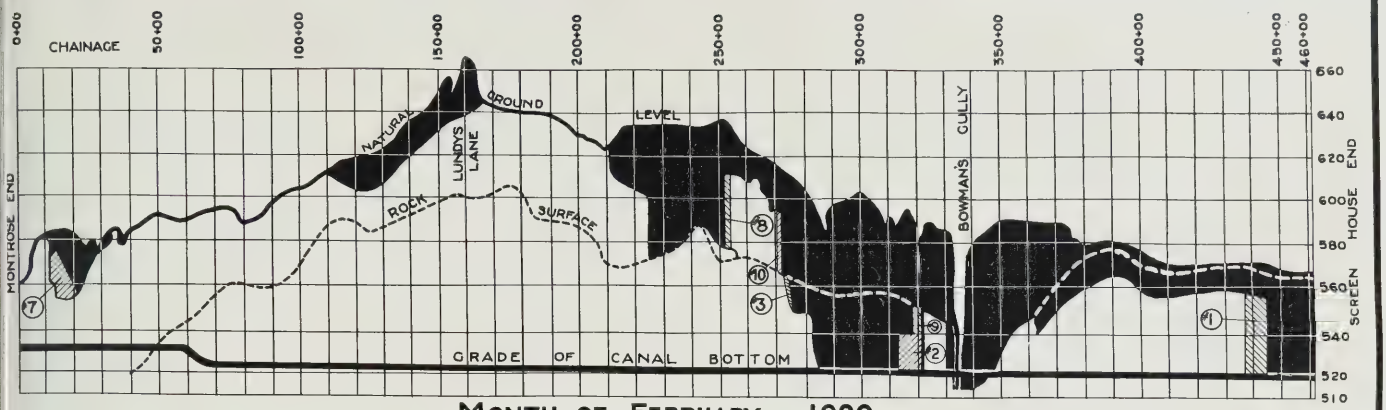
EXCAVATING UNITS SHOWN THUS:- #1

MILEAGE SHOWN THUS:- 4

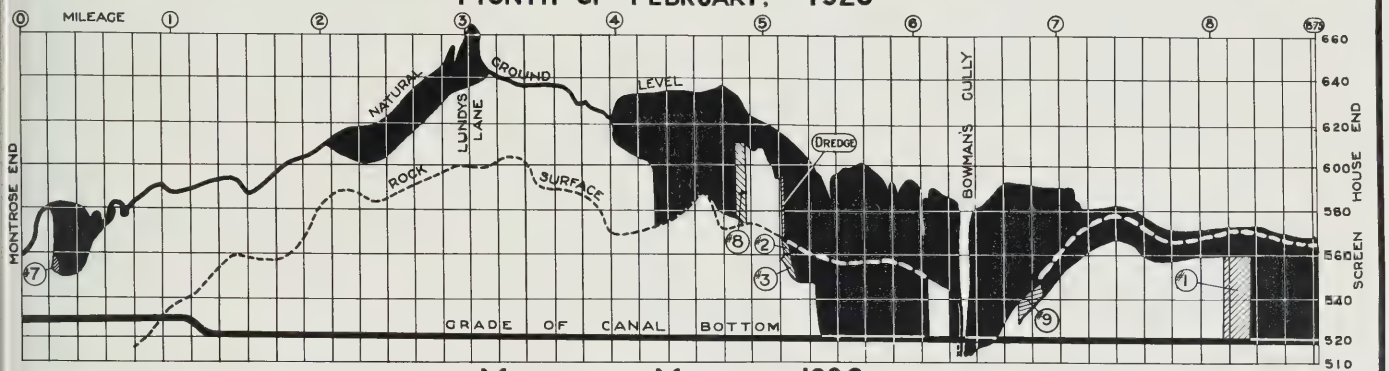
ELEVATIONS ARE REFERRED TO H.E.P.C. DATUM

Scale of Feet
Horizontal 0 5000
Vertical 0 10 20 30 40 50 60 70 80 90 100

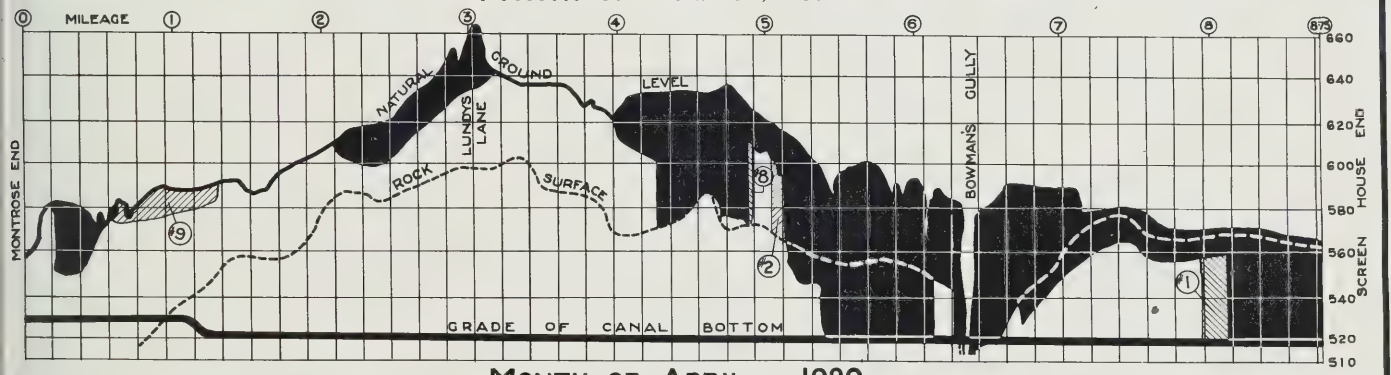
SHEET 4



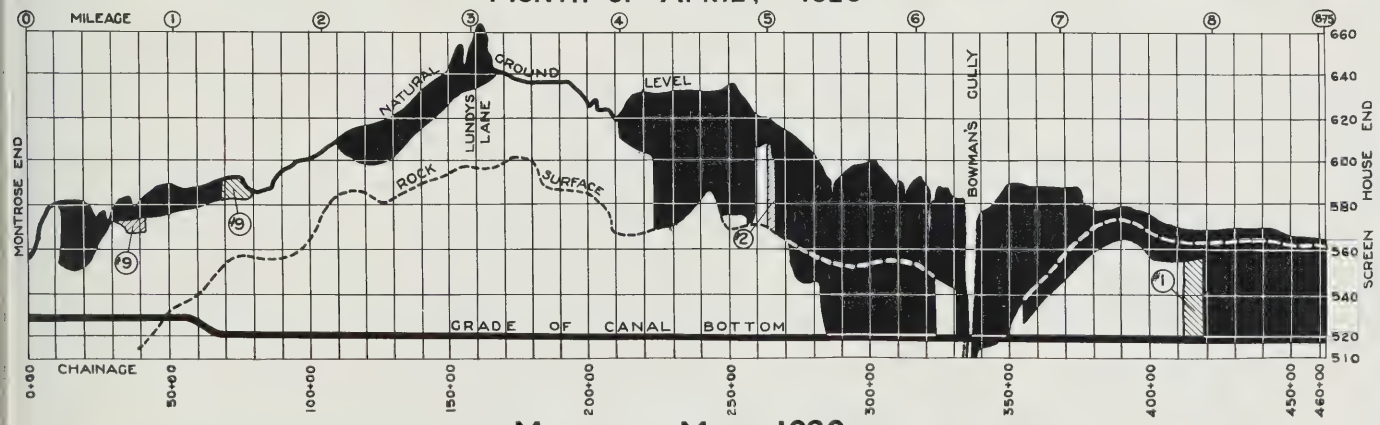
MONTH OF FEBRUARY, 1920



MONTH OF MARCH, 1920



MONTH OF APRIL, 1920



MONTH OF MAY, 1920

FEBRUARY, 1920 TO MAY, 1920

CAVATION DURING MONTH INDICATED, SHOWN THUS:-

" COMPLETED PRIOR TO MONTH INDICATED, SHOWN IN BLACK

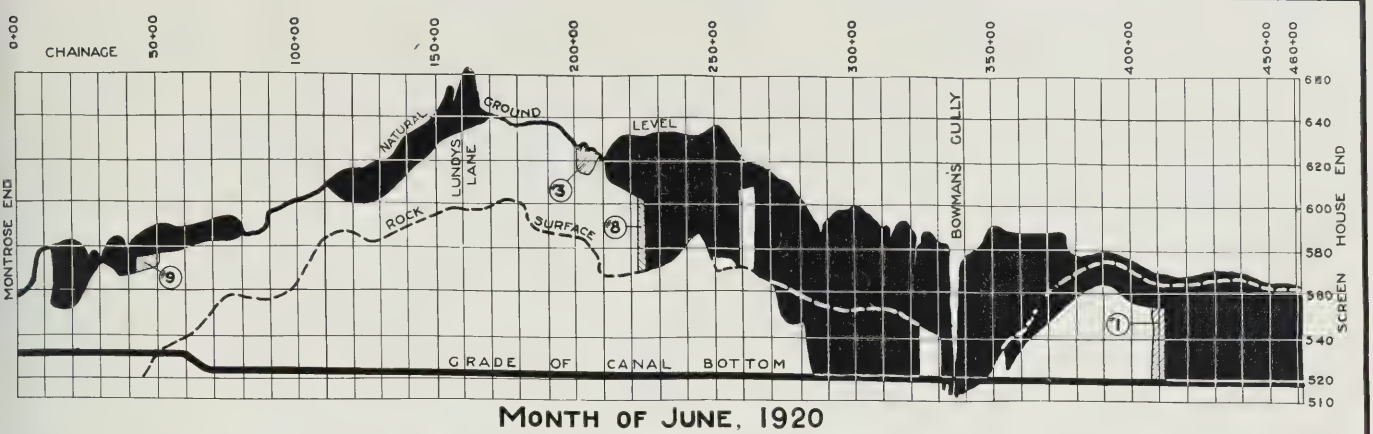
CAVATING UNITS SHOWN THUS:- (1)

LEAGE SHOWN THUS:- (4)

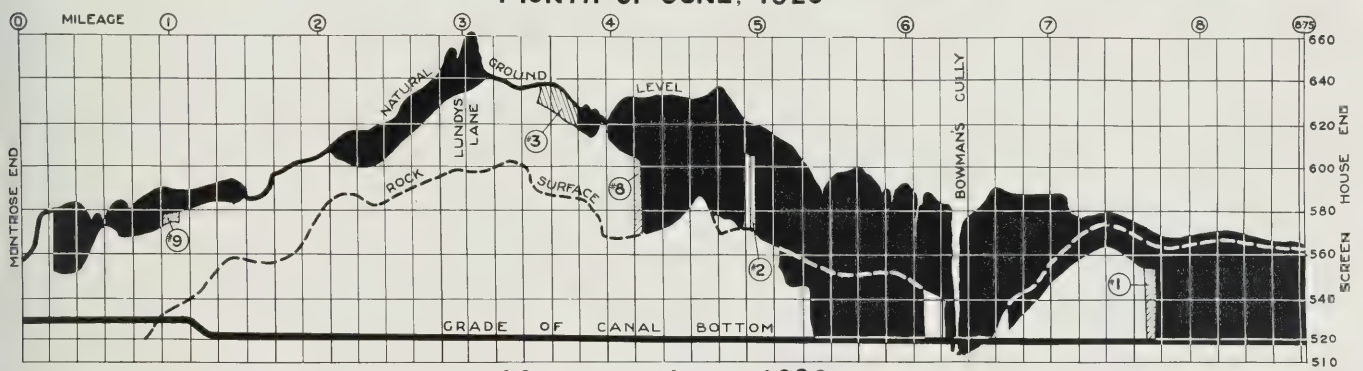
EVATIONS ARE REFERRED TO H.E.P.C. DATUM

Scale of Feet
Horizontal
0 5000
Vertical
0 10 20 30 40 50 60 70 80 90 100

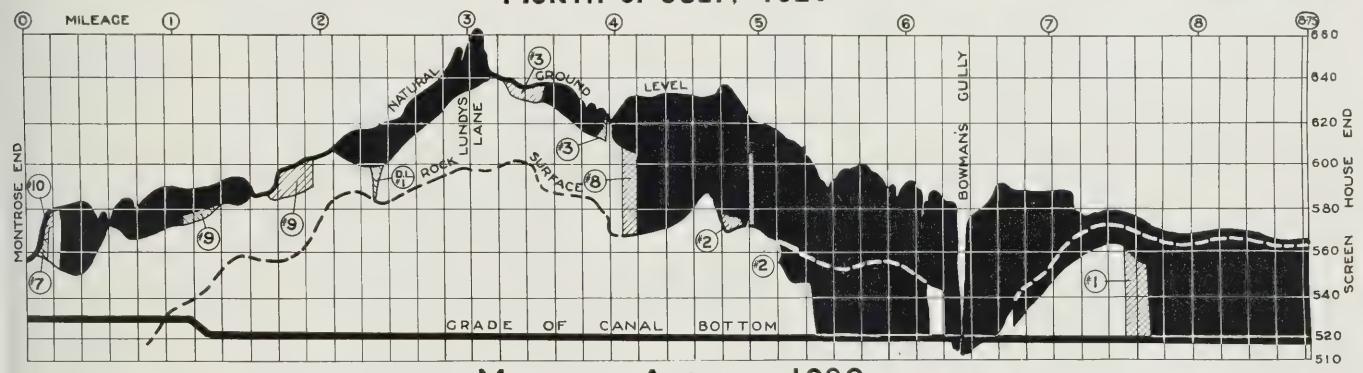
SHEET 5



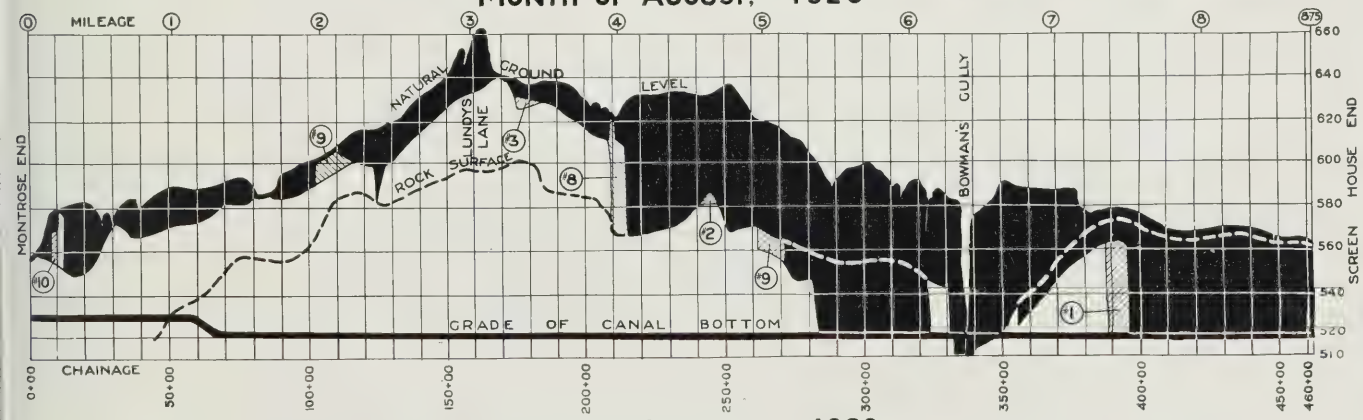
MONTH OF JUNE, 1920



MONTH OF JULY, 1920



MONTH OF AUGUST, 1920



MONTH OF SEPTEMBER, 1920

JUNE, 1920 TO SEPTEMBER, 1920

EXCAVATION DURING MONTH INDICATED, SHOWN THUS:-

" COMPLETED PRIOR TO MONTH INDICATED, SHOWN IN BLACK

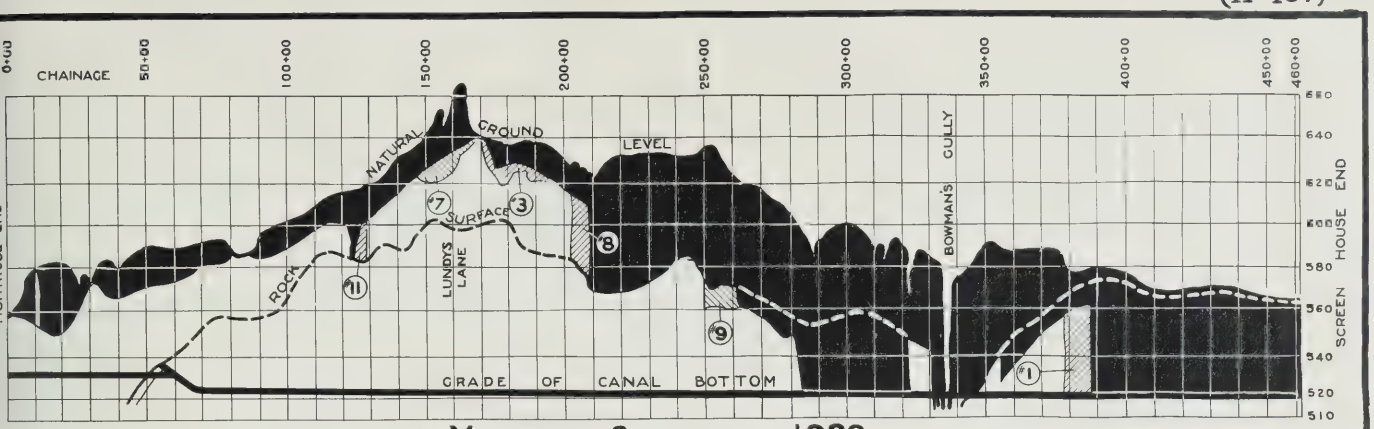
EXCAVATING UNITS SHOWN THUS:- #1

MILEAGE SHOWN THUS:- 4

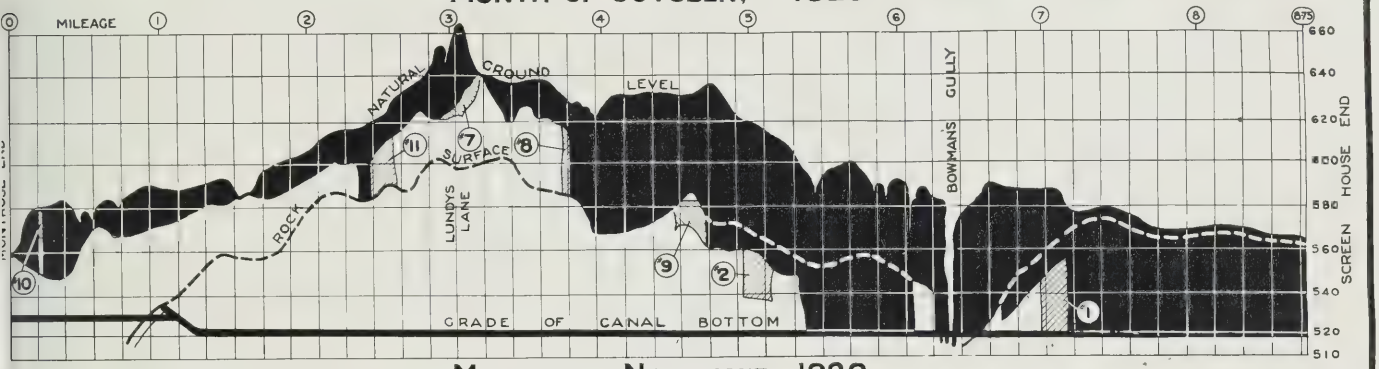
ELEVATIONS ARE REFERRED TO H.E.P.C. DATUM

Scale of Feet
Horizontal 0 5000
Vertical 0 10 20 30 40 50 60 70 80 90 100

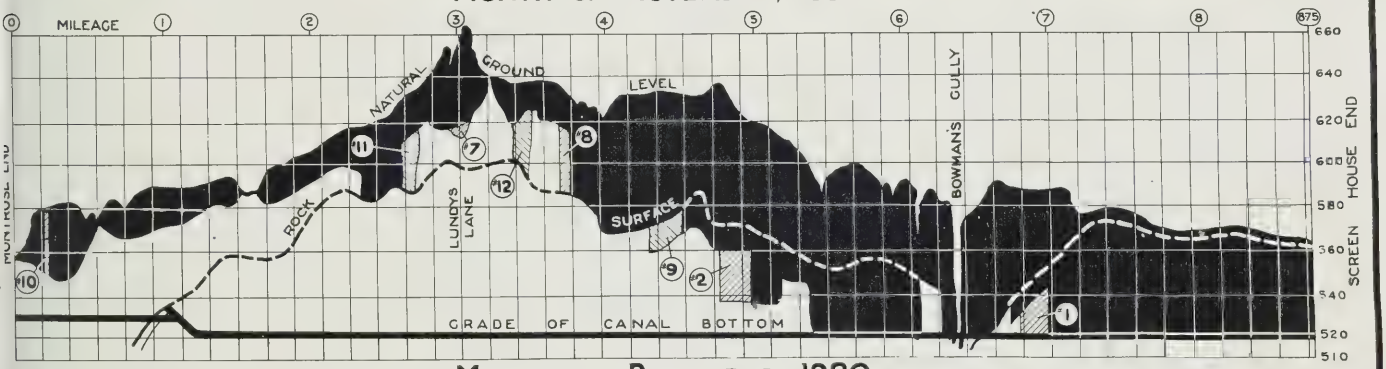
SHEET 6



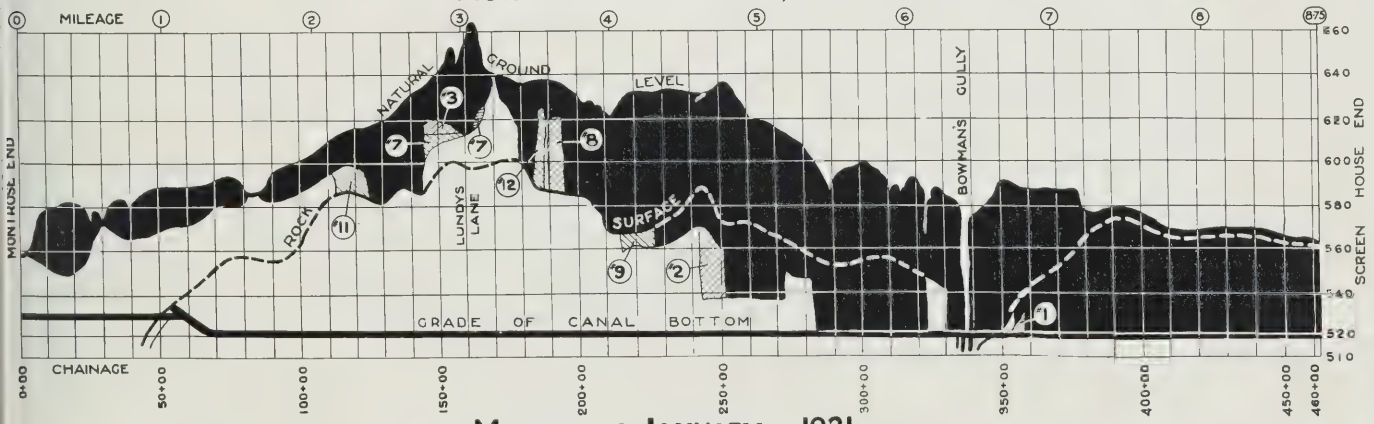
MONTH OF OCTOBER, 1920



MONTH OF NOVEMBER, 1920



MONTH OF DECEMBER, 1920



MONTH OF JANUARY, 1921

OCTOBER, 1920 TO JANUARY, 1921

EXCAVATION DURING MONTH INDICATED, SHOWN THUS:-

" COMPLETED PRIOR TO MONTH INDICATED, SHOWN IN BLACK

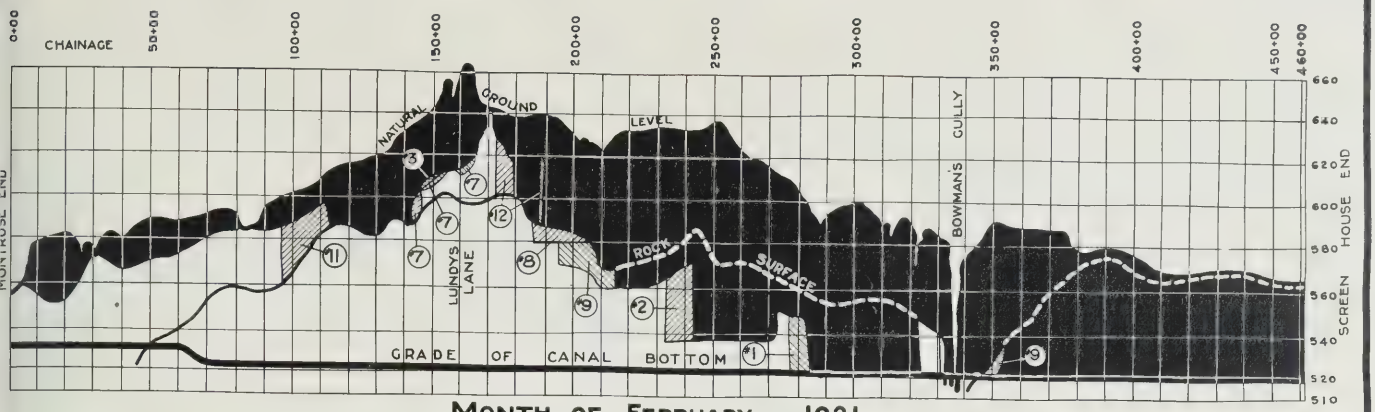
EXCAVATING UNITS SHOWN THUS:- #1

MILEAGE SHOWN THUS:- 4

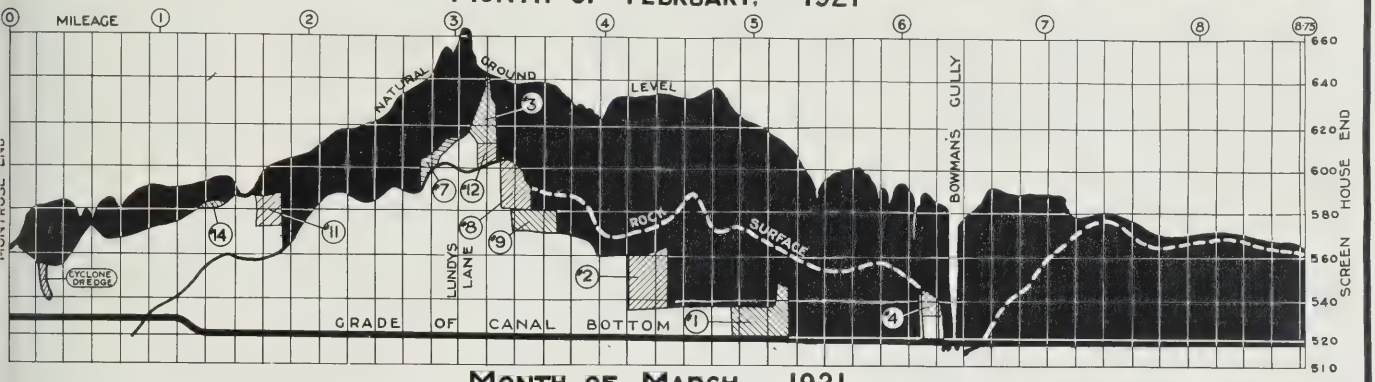
ELEVATIONS ARE REFERRED TO M.E.P.C. DATUM

Scale of Feet
Horizontal
0 5000
Vertical
0 10 20 30 40 50 60 70 80 90 100

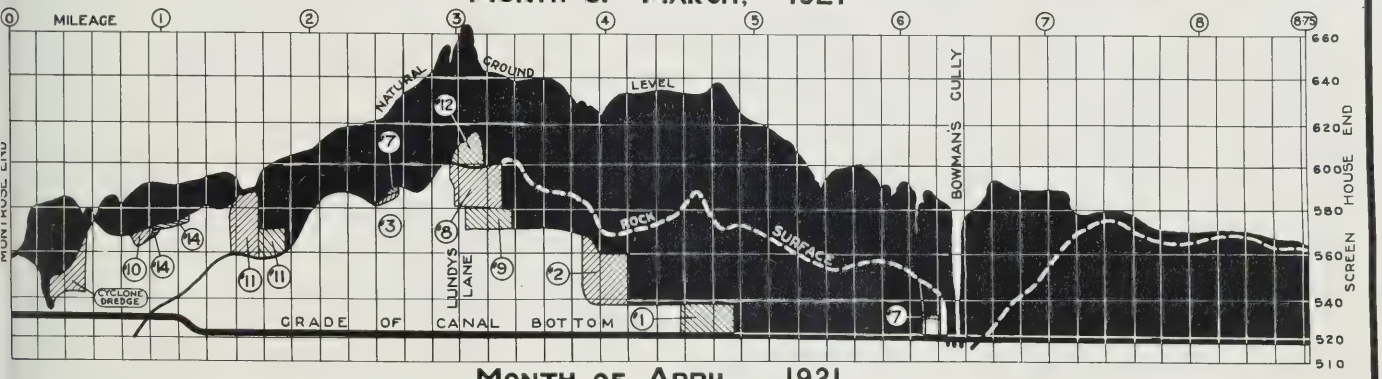
SHEET 7



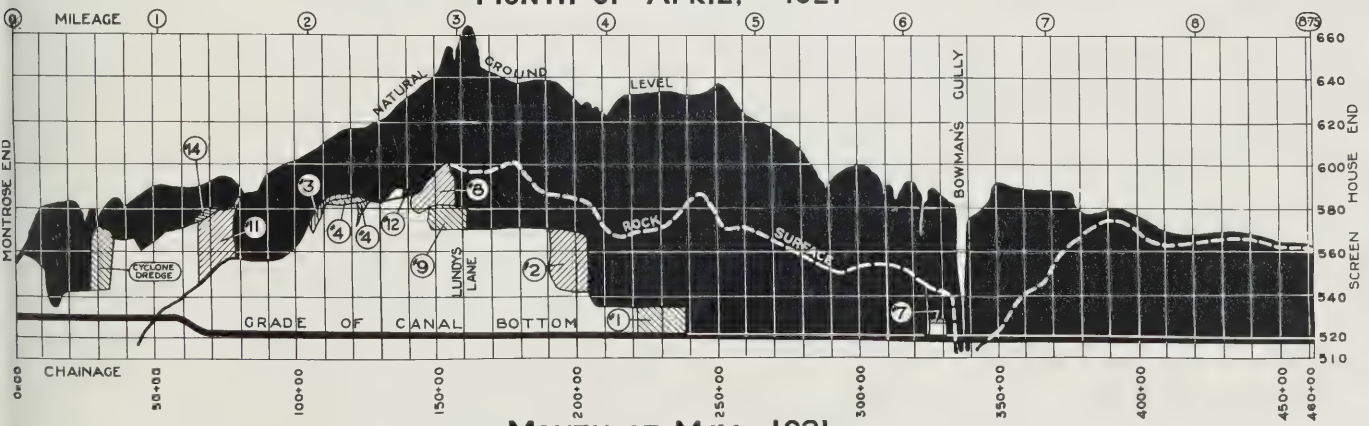
MONTH OF FEBRUARY, 1921



MONTH OF MARCH, 1921



MONTH OF APRIL, 1921



MONTH OF MAY, 1921

FEBRUARY, 1921 TO MAY, 1921

CAVATION DURING MONTH INDICATED, SHOWN THUS:-

" COMPLETED PRIOR TO MONTH INDICATED, SHOWN IN BLACK

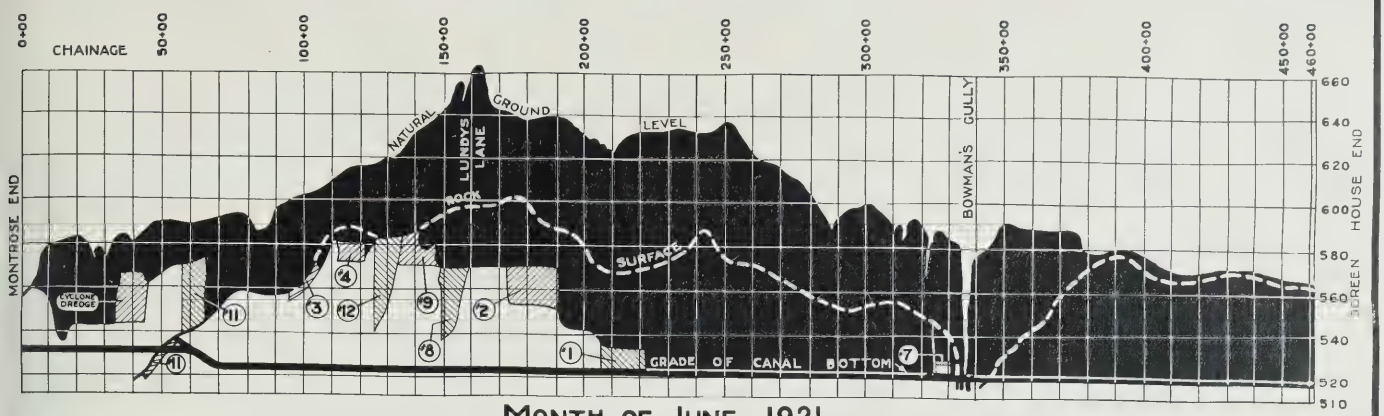
CAVATING UNITS SHOWN THUS:- (1)

LEAGE SHOWN THUS:- (4)

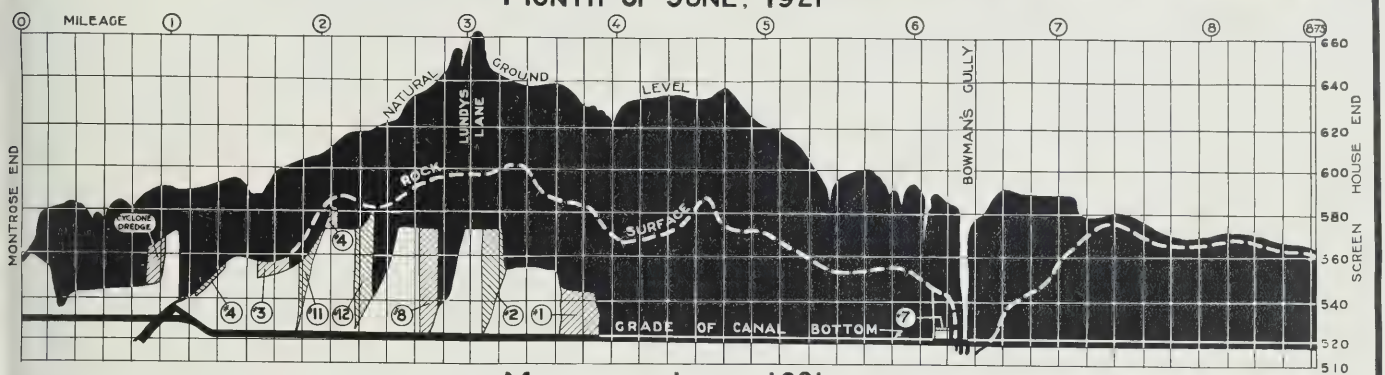
EVATIONS ARE REFERRED TO H.E.P.C. DATUM

Scale of Feet
Horizontal
0 5000
Vertical
0 10 20 30 40 50 60 70 80 90 100

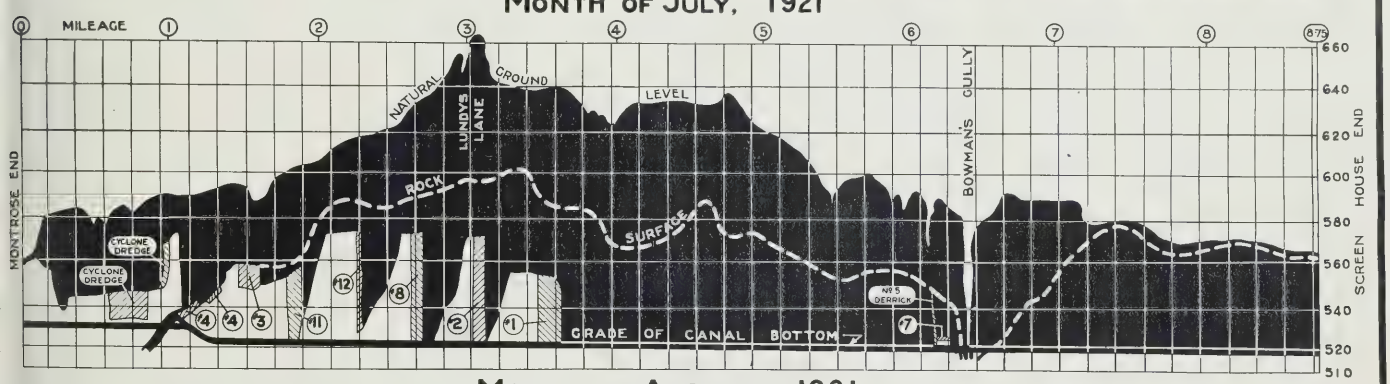
SHEET 8



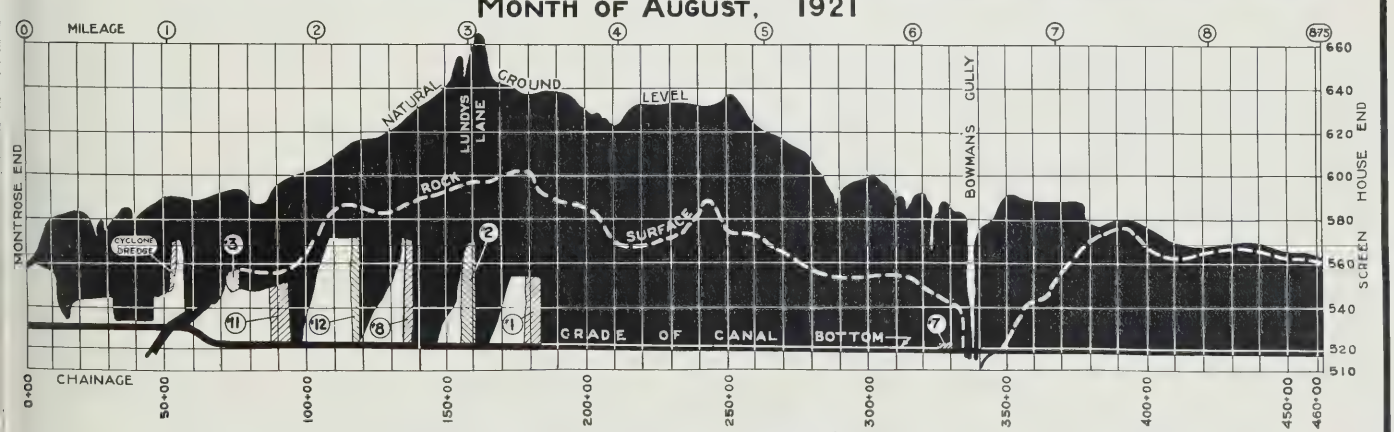
MONTH OF JUNE, 1921



MONTH OF JULY, 1921



MONTH OF AUGUST, 1921



MONTH OF SEPTEMBER, 1921

JUNE 1921 TO SEPTEMBER, 1921

EXCAVATION DURING MONTH INDICATED, SHOWN THUS:-

" COMPLETED PRIOR TO MONTH INDICATED. SHOWN IN BLACK

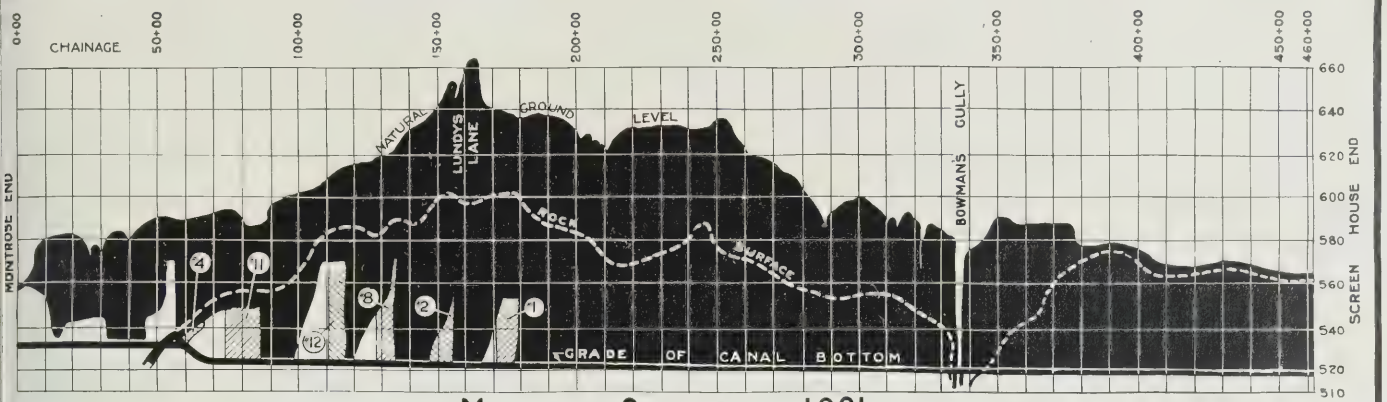
EXCAVATING UNITS SHOWN THUS:- (1)

MILEAGE SHOWN THUS:- (4)

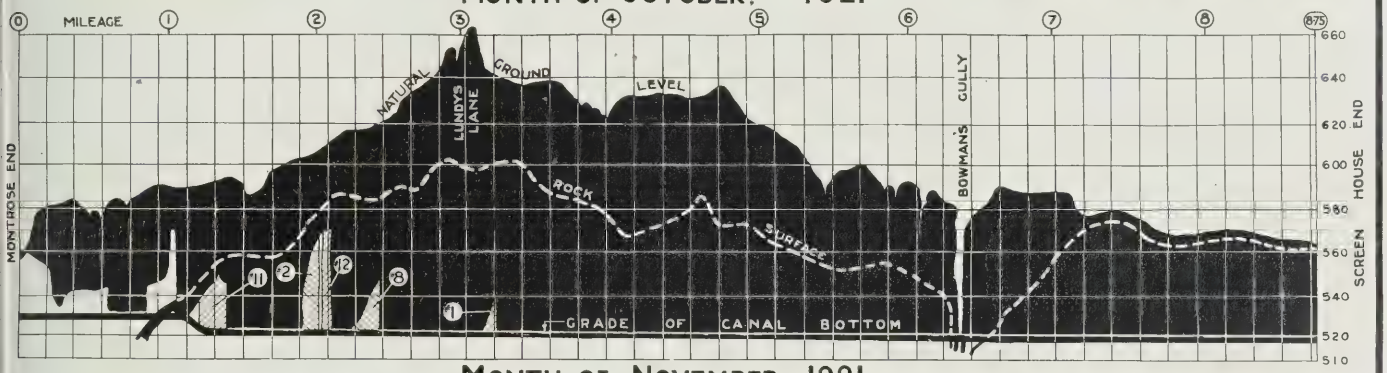
ELEVATIONS ARE REFERRED TO H.E.P.C. DATUM

Scale of Feet
Horizontal
0 5000
Vertical
0 10 20 30 40 50 60 70 80 90 100

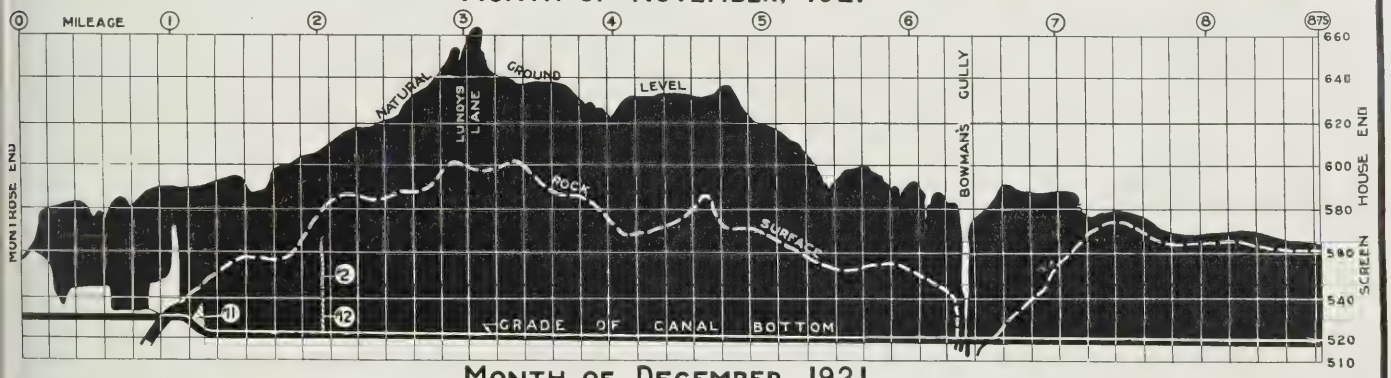
SHEET 9



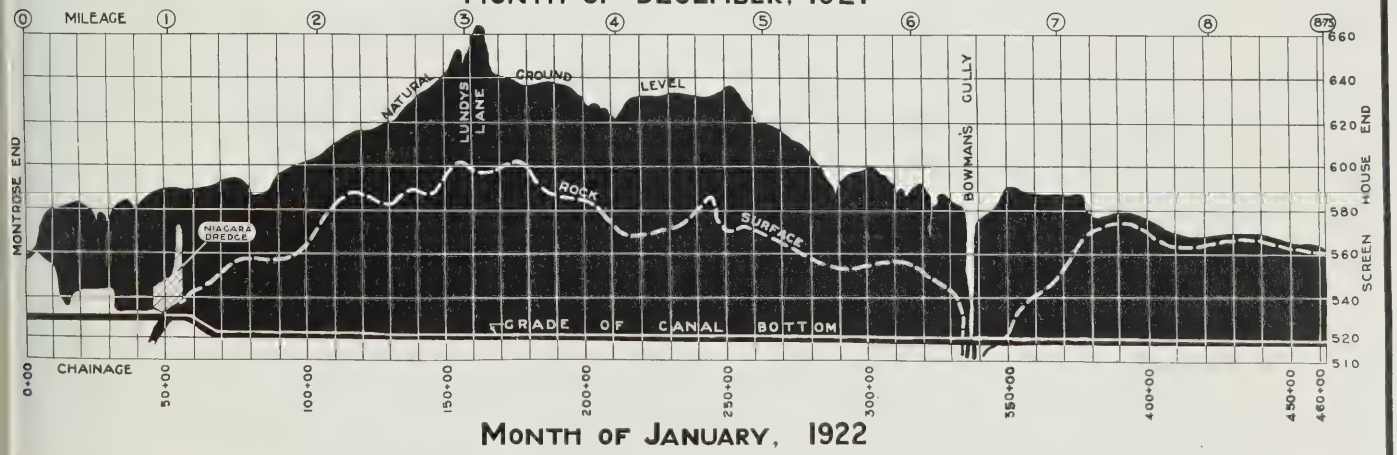
MONTH OF OCTOBER, 1921



MONTH OF NOVEMBER, 1921



MONTH OF DECEMBER, 1921



MONTH OF JANUARY, 1922

OCTOBER, 1921 TO JANUARY, 1922

CAVATION DURING MONTH INDICATED, SHOWN THUS:-

" COMPLETED PRIOR TO MONTH INDICATED, SHOWN IN BLACK

CAVATING UNITS SHOWN THUS:- (1)

LEAGE SHOWN THUS:- (4)

EVATIONS ARE REFERRED TO H.E.P.C. DATUM

Scale of Feet
Horizontal 0 5000
Vertical 0 10 20 30 40 50 60 70 80 90 100

SHEET 10

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Queenston-Chippawa Power Development

Table showing Total Quantities of Earth and Rock Excavated.

	E.S. #1	E.S. #2	E.S. #3	E.S. #4	S.S. #5	E.S. #6
1917:						
May						
June						
July						
August					5,599	
September					240	
October					810	
November					4,208	1,220
December			9,236		-	2,173
1918:						
January			26,256	7,396	2,339	1,560
February			24,065	14,715	-	2,806
March	8,300		32,912	11,749	-	-
April	42,840		[illegible]	21,068	-	472
May	44,378	15,666	2,245	4,463	-	2,579
June	51,589	19,930	5,715	1,291	3,975	6,927
July	80,449	-	28,042	-	3,229	7,548
August	107,350	43,938	13,660	579	5,750	2,595
September	4,600	53,005	17,297	-	1,008	4,447
October	57,116	46,629	11,519	2,527	-	9,750
November	66,085	25,258	949	22,631	-	3,000
December	45,888	43,239	21,429	24,445	-	723
1919:						
January	62,127	61,856	3,466	31,376	510	-
February	61,929	155,468	4,607	34,527	-	5,668
March	124,230	122,916	3,414	7,123	1,755	3,707
April	100,441	97,166	5,106	-	-	7,159
May	-	66,818	19,737	-	-	7,888
June	-	100,719	6,529	2,229	-	1,507
July	-	91,558	352	9,154	890	
August	-	57,367	15,021	12,799	1,076	
September	-	22,779	12,951	13,690	-	
October	-	31,985	51,669	-	-	
November	-	35,352	88,173	-	243	
December	4,960	40,378	51,179	-	3,977	

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

(H-141)

Canal Excavation Only

month by month, by the several Excavating Units

S.S. #7	S.S. #8	S.S. #9	S.S.#10	S.S.#11	S.S.#12	S.S.#14	Misc. Equip.
7,100							
20,100							
17,324							
14,982							2,025
11,885							1,827
7,592							25
17,329							125
13,207							-
3,136							-
1,211							-
-							8
-							510
-							48
-							-
-							1,500
5,534							-
13,711							-
914							-
-							-
3,270							-
1,380							-
-							700
-							1,813
-		335					1,917
-	5,600	47,092					2,089
-	56,279	75,591	1,477				11,398
2,690	130,469	89,646	10,663				7,306
37,220	175,803	128,059	4,321				6,648
56,847	97,448	27,443	6,091				15,229
46,457	102,665	71,885	700				4,237
42,072	130,363	64,749	1,732				5,370
22,031	45,298	9,279	1,449				6,596

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Queenston-Chippawa Power Development

Table showing Total Quantities of Earth and Rock Excavated.

	E.S. #1	E.S. #2	E.S. #3	E.S. #4	S.S. #5	E.S. #6
1920:						
January	65,445	34,308	44,242	-	4,888	
February	50,236	37,478	39,500	-	2,323	
March	68,152	2,498	18,348	-	-	
April	62,406	100,625	44,309	-	-	
May	47,761	63,146	81,015	-	-	
June	31,894	-	11,804	-	-	
July	24,938	38,904	27,958	-	1,250	
August	65,258	102,893	86,625	-	1,830	
September	69,978	53,340	93,518	-	1,521	
October	77,410	60,800	59,425	-	1,135	
November	69,017	41,512	55,058	62,788	3,099	
December	41,132	51,050	56,120	48,071	2,007	
1921:						
January	18,488	49,248	41,345	62,998	1,142	
February	34,796	53,313	28,490	28,482	5,421	
March	71,020	60,347	39,092	11,677	1,017	
April	60,567	78,839	10,835	8,291	-	
May	53,159	67,418	18,862	12,773	-	
June	55,449	69,885	17,757	19,275	-	
July	54,789	50,817	21,291	19,797	-	
August	43,395	34,065	15,734	8,021	-	
September	35,498	38,069	9,509	3,408	86	
October	44,291	35,935	15,570	5,633	2,158	
November	15,422	33,873	-	-	-	
December	-	2,001	-	-	-	
Totals	2,022,703	2,285,411	1,286,738	512,976	63,486	71,749

Note: In June, 1919, Shovel #6 (Electric) was moved to the Power House site and the Queenston-Power House Railway.

E.S. #1 denotes Shovel #1, Electric.
S.S. #5 denotes Shovel #5, Steam.

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

(H-142)

Canal Excavation Only

month by month, by the several Excavating Units (Continued)

S.S. #7	E.S. #8	E.S. #9	S.S.#10	S.S.#11	S.S.#12	S.S.#14	Misc. Equip.
20,945	47,543	11,173	9,755				3,941
22,700	74,470	12,267	5,707				8,449
39,285	77,904	15,094	-				13,278
48,670	40,249	60,361	-				6,310
21,952	70,863	45,418	-				8,047
-	75,021	24,929	-				150
-	40,021	12,632	-				-
8,427	124,468	75,533	8,634				9,554
71,438	161,601	41,728	17,218				-
57,475	121,730	24,107	13,472	38,810			-
56,317	78,272	23,259	6,684	100,028	2,000	1,552	-
43,433	90,596	16,588	10,169	79,939	75,150	-	5,147
42,304	122,966	23,230	9,922	87,210	85,869	14,525	2,028
32,741	46,304	35,713	9,473	148,968	108,695	29,464	-
21,536	56,217	28,613	6,667	128,467	121,931	35,732	4,068
9,327	69,059	25,400	20,111	135,533	137,854	26,985	7,116
3,612	65,197	25,551	7,685	158,036	69,635	32,311	10,312
11,897	46,475	25,379	-	186,310	50,545	22,773	6,946
7,234	55,647	48,784	-	25,380	38,369	62,916	14,749
5,045	33,385	51,581	-	51,850	17,614	16,713	13,050
5,250	27,021	57,436	-	35,795	24,983	-	6,892
-	39,724	-	-	35,798	38,808	-	24,593
-	32,290	-	-	46,146	31,457	-	19,871
-	-	-	-	1,549	4,136	-	3,523
93,158	2,340,948	1,198,817	152,130	1,259,819	807,240	242,971	234,393

Queenston-Chippawa Development - Canal Excavation Only

Table showing Quantities of Earth and Rock Excavated, year by year, by the several Excavating Units

	1917	1918	1919	1920	1921	Total
	Cu.Yds.	Cu.Yds.	Cu.Yds.	Cu.Yds.	Cu.Yds.	Cu.Yds.
Shovel No. 1.						
Earth		508,595	348,727	.....		857,322
Rock			4,960	673,627	486,794	1,165,381
Shovel No. 2.						
Earth		247,665	740,735	409,323	.....	1,397,723
Rock			143,627	177,226	566,830	887,683
Shovel No. 3.						
Earth	9,236	178,627	243,033	591,722	127,037	1,149,655
Rock		20,864	19,171	6,200	90,848	137,083
Shovel No. 4.						
Earth		55,161	11,383	110,859	95,714	273,117
Rock		55,703	99,515	.....	84,641	239,859
Shovel No. 5.						
Earth	10,857	15,892	8,451	7,211	6,901	49,312
Rock		409	.....	10,842	2,923	14,174
Shovel No. 6.						
Earth	3,393	42,427	25,929	.....	.....	71,749
Rock						
Shovel No. 7.						
Earth.....	109,519	22,084	227,317	390,642	103,697	853,259
Rock		3,270	1,380	.....	35,249	39,899
Shovel No. 8.						
Earth			743,925	1,002,738	129,759	1,876,422
Rock					464,526	464,526
Shovel No. 9.						
Earth			501,293	239,169	157,801	898,263
Rock			12,756	123,912	163,886	300,554
Shovel No.10.						
Earth			26,433	71,639	54,058	152,130
Rock						
Shovel No.11.						
Earth				218,777	830,992	1,049,769
Rock					210,050	210,050
Shovel No.12.						
Earth				77,150	519,563	596,713
Rock					210,527	210,527
Shovel No.14.						
Earth				1,552	241,419	242,971
Rock						
Miscellaneous Equipment						
Earth	3,992	1,508	48,104	54,176	33,004	140,784
Rock	10	558	15,199	700	77,144	93,609

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Queenston-Chippawa Power Development

Table showing Daily Average Quantity of Earth and Rock Excavated.

	E.S. #1	E.S. #2	E.S. #3	E.S. #4	S.S. #5	E.S. #6
1917:						
May						
June						
July						
August					560	
September					40	
October					202	
November					421	111
December			659		-	310
1918:						
January			1,141	435	292	144
February			1,146	700	-	401
March	638		1,266	451	-	-
April	1,647		3,081	810	-	23
May	1,643	2,238	-	496	-	122
June	3,034	3,321	519	430	331	301
July	3,094	-	1,078	-	248	302
August	4,129	1,757	546	193	287	118
September	766	2,304	720	-	126	247
October	2,284	2,913	959	632	-	361
November	2,753	1,403	-	905	-	125
December	1,995	1,880	2,678	905	-	103
1919:						
January	2,301	1,933	1,155	1,012	510	-
February	1,935	3,239	921	885	-	377
March	2,389	2,410	189	-	292	195
April	2,643	1,943	150	-	-	286
May	-	1,285	858	-	-	303
June	-	2,098	435	202	-	100
July	-	2,032	-	1,144	445	-
August	-	1,5[illegible]9	626	319	269	-
September	-	518	432	334	-	-

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(H-144)

Canal Excavation Only

month by month, by the several Excavating Units

S.S. #7	E.S. #8	E.S. #9	S.S.#10	S.S.#11	S.S.#12	S.S.#14
546						
804						
666						
788						
1,188						
584						
666						
660						
-						
-						
-						
-						
-						
-						
-						
1,107						
623						
457						
-						
-						
460						
-						
-						
-		167				
-	1,120	-				
-	1,655	1,757	75			
224	2,662	1,793	237			
1,634	3,516	2,511	84			
1,160	2,030	1,525	218			

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Queenston-Chippawa Power Development

Table showing Daily Average Quantity of Earth and Rock Excavated.

	E.S. #1	E.S. #2	E.S. #3	E.S. #4	S.S. #5	E.S. #6
1919 (continued.						
October	-	627	1,148	-	-	
November	-	721	1,837	-	243	
December	451	897	1,163	-	181	
1920:						
January	1,235	686	885	-	196	
February	1,142	914	1,519	-	774	
March	1,311	250	459	-	-	
April	1,328	2,236	1,108	-	-	
May	995	1,857	1,841	-	-	
June	1,226	-	908	-	-	
July	639	1,111	932	-	78	
August	1,255	2,189	1,7[illegible]	-	70	
September	1,372	1,721	1,9[illegible]	-	138	
October	1,548	1,737	1,486	-	189	
November	1,327	865	1,124	1,207	-	
December	807	1,001	803	1,068	-	
1921:						
January	1,541	985	962	1,500	-	
February	828	1,088	1,239	633	217	
March	1,315	1,118	1,086	225	38	
April	1,164	1,516	241	173	-	
May	1,022	1,348	337	261	-	
June	973	1,456	555	459	-	
July	1,054	1,059	444	430	-	
August	1,173	971	629	573	-	
September	887	929	455	227	17	
October	1,055	1,198	1,298	282	154	
November	1,714	753	-	-	-	

Note: In June, 1919, Shovel #6 (Electric) was moved to the Power House site and the Queenston-Power House Railway.

E.S. #1 denotes Shovel #1, Electric.
S.S. #5 denotes Shovel #5, Steam.

Canal Excavation Only

month by month, by the several Excavating Units (Continued)

S.S. #7	E.S. #8	E.S. #9	S.S.#10	S.S.#11	S.S.#12	S.S.#14
1,032	2,053	1,467	70			
935	2,774	1,541	157			
595	1,224	357	104			
403	880	294	199			
597	1,959	361	258			
755	1,855	314	-			
1,136	1,059	1,207	-			
878	1,417	1,376	-			
-	2,885	1,917	-			
-	1,334	601	-			
444	2,394	1,481	432			
1,520	3,108	852	383			
1,197	2,590	541	306	1,021		
1,149	1,779	447	171	1,924	200	172
905	1,776	325	216	1,859	1,503	-
881	2,510	474	331	1,982	1,717	454
799	945	744	211	3,194	2,218	670
653	1,004	530	190	2,424	2,217	701
187	1,354	498	394	2,711	2,506	529
903	1,304	511	607	3,099	1,369	621
-	894	529	-	3,881	903	393
-	959	976	-	552	711	1,165
-	1,012	1,359	-	861	1,036	1,671
-	819	1,511	-	1,023	543	-
-	923	-	-	688	761	-
-	1,153	-	-	982	584	-

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(H-146)

Niagaston-Chippawa Power Development

Summary of Information regarding Excavating Units for Total Excavation Work in the Dry

Unit No.	Motive Power	Date Received	Earth Excavated	Rock Excavated
1	Electric	Dec. 25th, 1917	859,345	1,519,175
2	Electric	Dec. 25th, 1917	1,487,230	887,683
3	Electric	Nov. 30th, 1917	1,279,088	157,923
4	Electric	Dec. 11th, 1917	356,849	572,651
5	Steam	May 27th, 1917	169,628	14,174
6	Electric	Nov. 3rd, 1917	118,542	60,167
7	Steam	May 3rd, 1917	914,857	83,597
8	Electric	Mar. 31st, 1919	1,876,422	464,526
9	Electric	Mar. 31st, 1919	1,011,840	300,554
10	Steam	June 14th, 1919	171,604	-
11	Steam	Sept. 9th, 1920	1,049,769	210,407
12	Steam	Nov. 9th, 1920	596,713	210,527
13	Steam Ditcher	Oct. 14th, 1920	16,484	-
14	Steam	Nov. 1st, 1920	248,843	-
Miscellaneous			265,506	181,544
Totals			10,422,620	4,662,928
Additional quantities from final estimate, not distributed to units			42,363	77,031
	Total Cubic Yards		10,464,983	4,739,959

Sub-aqueous Excavation.

The rock line intersected the grade line of the floor of the Canal about a mile from the Welland River at the Montrose end. More precisely, the rock surface intersected the grade line of the floor of the Canal at Station 47+00 and rose on a slope of about one in thirty in the northerly direction. The excavation down to about Station 55 was therefore taken out as sub-aqueous work after the upper part, averaging about 20 feet in depth, had been removed by the dry-excavation equipment. Water was admitted from the Welland River through a by-pass canal paralleling the Michigan Central Railroad tracks and about 300 feet northerly therefrom. A suction dredge was then used to remove the earth in the Canal down to a flat bottom averaging Elevation 538. The yardage removed by the dredge amounted to approximately 1,100,000 cubic yards.

The manner of making the excavation may be clearly seen by reference to photograph No. H-78 which shows the "Cyclone" in operation shortly before it completed its task. At this time the dredge was within about one hundred yards of the portion of the Canal that had been excavated in the dry.

The dredge discharged the material on disposal areas located on the westerly side of the Canal, the location of which may be seen by reference to the plan of the disposal areas shown on page H-84 in the part of Chapter H on Construction Plant for Transportation.

The dredge operated for 204 working days between December 10th, 1920, and September 3rd, 1921.

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To face page H-148

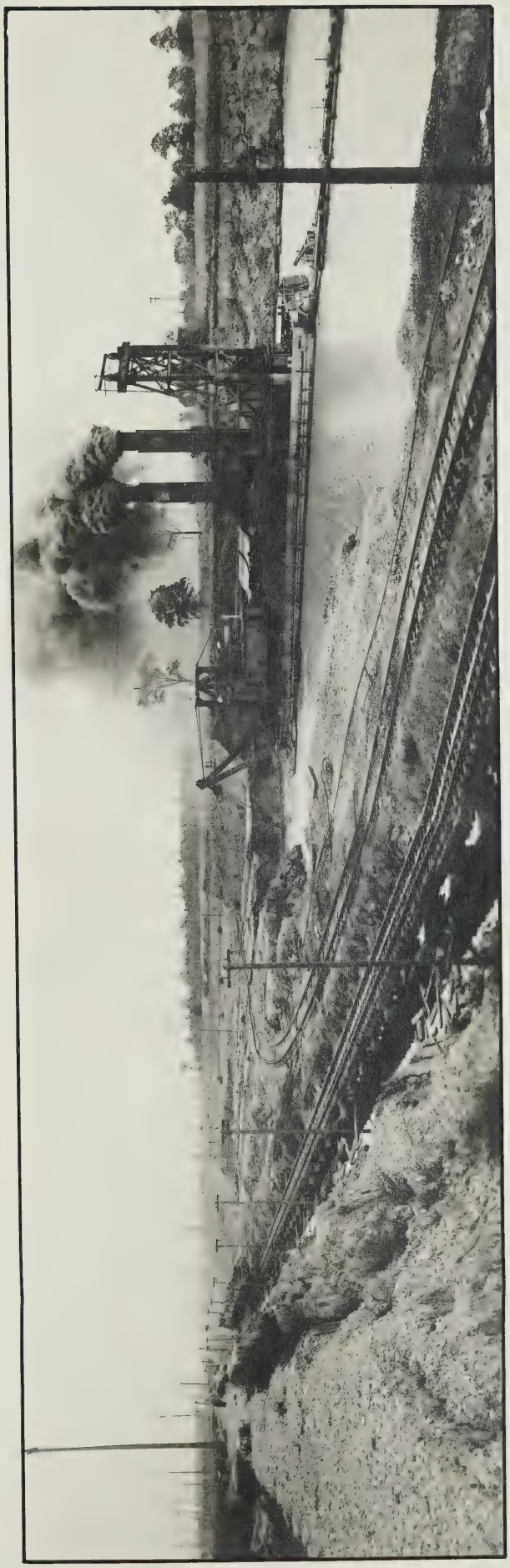
No. H-78

Photograph showing

COPY

Dredge "Cyclone" in Operation at Station 49.

Taken August 30th, 1921.



The details of the dredge "Cyclone" may be appreciated by reference to photographs Nos. H-79 and H-80 on page H-150 hereof, the former picture showing a side elevation of the dredge together with its "A" frame and deck arrangements, and the latter showing the boom and the cutter raised out of the water.

The rated capacity of the dredge was stated by the Toronto Harbour Commissioners to be not more than 4,000 cubic yards per day of 24 hours in material of the nature encountered. The boiler capacity of the dredge was 1,200 horse-power, and the coal consumption about 50 tons of bituminous coal per twenty-hour day. The discharge pipe of the dredge was 24 inches in diameter.

The "Cyclone" was not purchased by the Hydro-Electric Power Commission but was rented from the Toronto Harbour Commissioners for a total lump sum price of $250,000. By the terms of the contract the Harbour Commissioners delivered the "Cyclone" to the Hydro-Electric Power Commission at Toronto on the 29th day of November, 1920, complete with all equipment, and the Hydro-Electric Power Commission agreed to return the dredge with its equipment, complete in all respects and in condition similar to that when received, to the Harbour Commissioners on or before the 15th day of September, 1921. In addition, the Hydro-Electric Power Commission undertook to insure the dredge and its equipment against fire and marine risks in the sum of $1,000,000, and the pontoons accompanying it in the sum of $100,000, the Hydro-Electric Power Commission to bear the cost of the premiums. By a supplementary agreement, the Hydro-Electric Power Commission undertook to pay the Harbour Commissioners $350,000 in case of loss of the dredge on the trip to and from Chippawa in lieu

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To face page H-150

No. H-79

Photograph showing

Side View of the Dredge "Cyclone".

Taken December 13th, 1920.

COPY

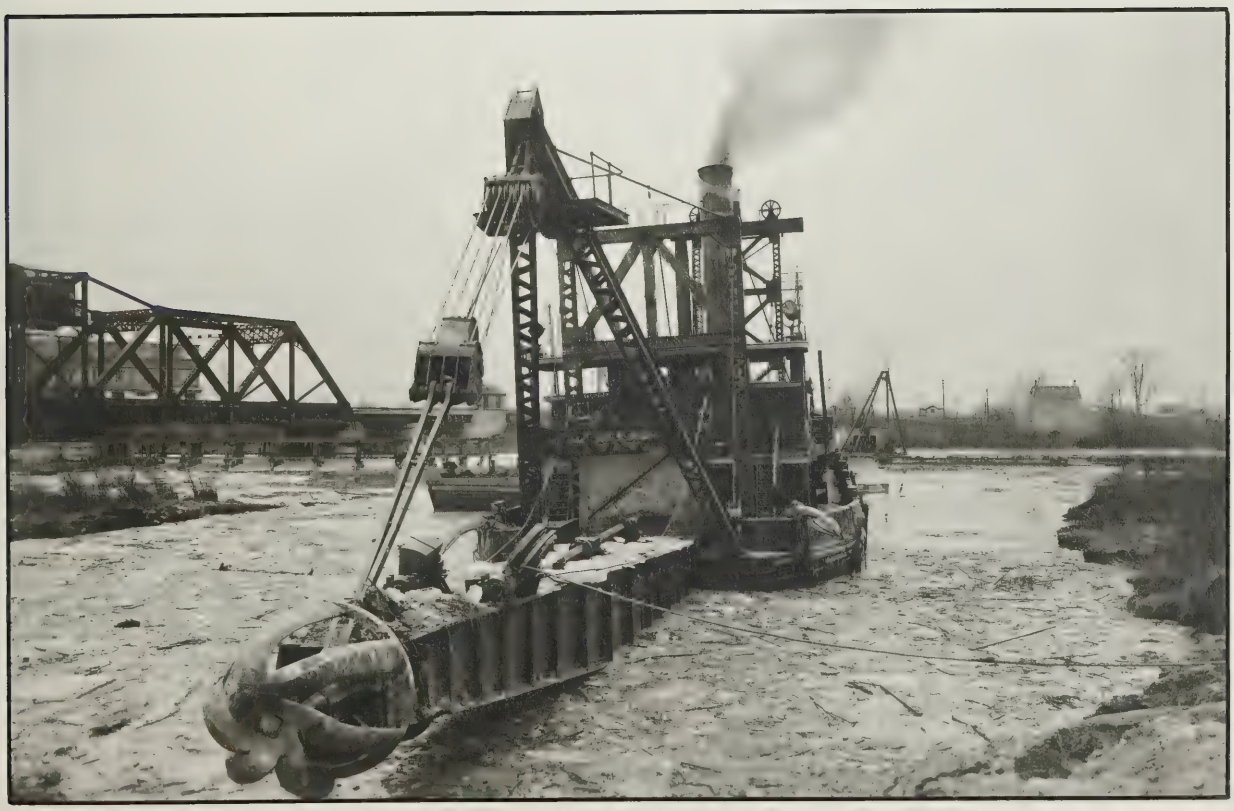
No. H-80

Photograph showing

"A" Frame, Boom and Cutter of Dredge "Cyclone".

Taken February 1st, 1921.


CYCLONE



of providing the before-mentioned insurance. There were other conditions in the way of penalties and so forth, but they were not called into action because the Hydro-Electric Power Commission was able to fulfil its part of the agreement and the "Cyclone" after finishing its work on September 3rd, 1921, was duly returned to the Toronto Harbour Commissioners at Toronto.

In taking the dredge from Toronto to Chippawa, the Hydro-Electric Power Commission took the risks incident to the lateness of the season, and succeeded in delivering the dredge into the Welland River almost the exact day of the close of navigation. After arriving, it had to be repaired and made ready, and the disposal areas had to be prepared. The actual excavation was commenced on March 14th, 1921. The progress made by the dredge "Cyclone" was as follows:

Date	Quantity
March, 1921	124,970 cubic yards
April, 1921	157,349 cubic yards
May, 1921	166,541 cubic yards
June, 1921	209,802 cubic yards
July, 1921	212,359 cubic yards
August, 1921	157,973 cubic yards
Sept. 1921	57,239 cubic yards
Total	1,086,233 cubic yards

On the completion of the excavation by the dredge "Cyclone" the Hydro-Electric Power Commission entered into a contract with John E. Russell for the excavation of 30,000 cubic yards of sub-aqueous earth work at the junction between the Welland River and the entrance to the Canal, and at the commencement of the rock section, at a price of 70 cents per cubic yard. The work was done by Mr. Russell with the dredge "Niagara" (since called the "Hennessy"), a suction dredge with a 14-inch discharge pipe. Mr. Russell provided his

of providing the Indo-Australian Lancaster. Much more other problems in the way of permitting such an flight, but they were not such. If they problem between the Ugra-Bharata Lower Commission was able to [illegible] the part of the agreement and the "Ugrians" after finishing the work on Bharatiya Ban, that, was duly returned to the Tonsaria Harbour Commissioners at [illegible].

In taking the Lancaster from Shamsir to Ghiyaru, the Ugra-Bharata Lower Commission took the risks inherent to the I Tonsaria of [illegible], an accepted in delivering the design into the [illegible] Lower [illegible] the [illegible] date of the close of negotiation. Some months, it had to be regarded not more ready, and the disposal issue had to be postponed. The [illegible] [illegible] [illegible] [illegible] [illegible] 1941.

[illegible], 1941	[illegible]
[illegible], 1941	[illegible]
May, 1941	[illegible]
[illegible], 1941	[illegible]
[illegible], 1941	[illegible]
[illegible], 1941	[illegible]
Total	[illegible]

own plant for the work, and the Hydro-Electric Power Commission acquired no right of proprietorship therein.

Walter J. Francis

Consulting Engineer.

Toronto, March 21st, 1923.

COPY